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DOCTOR A. K. MORDWILKO

In Memoriam

On July 12, 1938, in Russia, died Dr. Alexander K. Mordwilko, at the age of seventy-one, widely known to the world as an eminent entomologist of the old Russian School. He was an authority in his native land, in Imperial Russia, as well as during the present Soviet Regime, in a comparatively restricted field of entomology, having specialized in the taxonomy of the Aphididae. His fundamental works in the field of Aphidology are used extensively in the original and as translations everywhere. He was born February 3, 1867, in Southern Russia, graduated from the University of Warsaw (then in Russia) from the natural science division of the physio-mathematical faculty. For a while, he was assistant to Dr. N. V. Nassonov. In 1901 he successfully defended his dissertation in the University of Kiev. From 1911 he held the position of zoologist in the Zoological Institute of the Russian Academy of Sciences in St. Petersburg (then Petrograd and finally Leningrad) University. From 1918–1922 he lectured also in the Agricultural Institute in Petrograd. In 1925 he received the "P. P. Semenov-Tianshansky's Prize" from the Russian Entomological Society. In spite of the fact that he specialized in a very restricted field of science, he has left a lasting monument as a result of his thirty-seven years of uninterrupted scientific work—his system of classification which is the basis for Aphidology. It is of immense value to theoretical entomology as well as to the applied science.

He left more than eighty publications including ten books, a list of which is presented at the end of this article. The author of this note had a chance to meet Dr. Mordwilko in old St.

Petersburg in the Zoological Museum of the Academy of Sciences and also during the meetings of the Russian Entomological Society but a more intimate acquaintance took place in 1913 in Stravropol-on-Caucasus, where the author was assistant director in the local Bureau of Plant Protection. The visit of Dr. Mordwilko took place so late in the season that one would have thought it was hardly possible to make even one field trip of entomological interest. There was certainly not much insect life visible and the dull landscape presented by the dried-out vegetation did not add to the prospects. But to the author's astonishment, Mordwilko insisted on an immediate field trip and expressed his confidence that he would fill with specimens his thirty small glass tubes each about two inches long and filled with alcohol. Equipped with a hand lens, the thirty glass tubes, and a net, he boldly set out to attack the mysteries of dormant nature, invading the forests and fields just outside the town with the vigor and ardor of an enthusiast. In his presence, the invisible was brought to light. He showed the buds and the twigs covered with aphid eggs. He made lists including the Latin names of the species of both the plants and the aphids. During the first half hour, he uprooted many different species of plants predicting without mistake before the plant was pulled up what would be on the roots. The author of this note tried to help him by pulling up additional plants, but to his astonishment, there were no root aphids on those he had pulled out in spite of the fact that they were plants of the same species that Mordwilko had selected. Soon was discovered, without explanation from him, the cause of the mistake. In order to find an aphid colony at the roots, one must pay attention not only to the species and condition of the plant but also to the presence or absence of ant activity in the immediate vicinity. Dr. Mordwilko's energy and enthusiasm during that single trip was contagious. With red cheeks and bright eyes sparkling through his spectacles, though middle-aged and round, he roamed in every direction—cutting twigs, pulling up plants and crushing clods of dried earth with the agility of a boy. He managed even to catch a few winged forms in the air, announcing immediately from what host-plant they had taken off and what their destination would be. He explained his theory of migration, its cause and its significance, at that time in the stage of formation.

Many years later in the United States the undersigned learned with what respect the name of Mordwilko was pronounced by his American colleagues particularly by Professor H. F. Wilson, whom the undersigned met at Madison, Wisconsin. This last mentioned scientist frankly admitted that in his system of classification and description of Aphididae from species of Artemisia and related plants of the Northwest, he used Mordwilko's system as a guide.

From the few letters obtained in the United States from the late Mordwilko since the Russian Revolution, letters written in unusually small and frail characters typical of a scientist, with several pages devoted to theories, requests and desiderata, one request is well remembered; the late Mordwilko wanted aphids from California poison oak and several other plants characteristic of the Pacific Coast. All those requests were in connection with the desire of the late scientist to check his observations on the causes of migration and changes of hosts by the Aphididae during a season. He suggested that the causes of migration were not only the seasonal changes in temperature but more drastic changes in climatic conditions on the earth's surface in the remote past. The latest and most drastic changes were the corresponding periods of widespread glaciation in both Eurasia and sections of North America. He had found considerable proofs of his theory in Eurasia and his restless, penetrating mind was searching for evidences in North America and especially in California.

The extra-curricular wanderings of the undersigned were not of much help to the late Mordwilko in fulfilling his desire to collect material for proof of his theory. The undersigned left it to better established and more permanently located sons of America working in the same field as the great Russian scientist.

D. N. Borodin,
New York.

(Former member of the Russian Entomological Society and former Associate Member of the American Association of Economic Entomologists.)

BIBLIOGRAPHY OF SOME OF THE MORE WIDELY USED WORKS OF DR. A. K. MORDWILKO

The titles have been translated into English by D. N. Borodin. The journal names follow the usage in the "Union List of Serials." Some have been checked against the "List of Foreign Government Publications" (H. W. Wilson Co., New York City). Mrs. Ethel Melsheimer Miller, Department Librarian, Zoology and Entomology, Ohio State University, who has made these checks has also used the Zoological Record, the Review of Applied Entomology, Biological Abstracts, the Concilium Bibliographicum, and has checked many of the articles back against the original publications. The Editor wishes to thank Mrs. Miller for the several days of work involved.

Five articles, the status of which could not be settled in the Library of Ohio State University, were referred to the Library of Congress where Mr. Frederick E. Brasch, Chief of the Smithsonian Division, gave generously of his time. It was he who called our attention to the bibliography of works by Mordwilko on page 59 of the Archiv für Naturgeschichte (Zeitschrift für systematische Zoologie) Neue Folge, Band 3, 1 Heft. Leipzig, 1934. (See our item No. 76.)

Nos 2, 5, 9, 15, 23, 24, 28, 60, and 64 are books in size, ranging from 36 pages to 936 pages.

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4. Zur Anatomie der Pflanzenläuse, Aphiden. (Gattungen: Trama Heyden und Lachnus Illiger.) *Ibid.*, 18 (1895): 345–364, 402.
5. On the biology of the plant lice of the sub-families Aphididae and Pemphigidae. (In Russian.) Rabot. Lab. Zool. Kab. Varshav. Univ. 1896: 23–146. [Travaux du Cabinet Zoologique de l'Université Impériale de Varsovie (Warsaw).]
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15. The origin of the phenomenon of intermediary hosts among animal parasites. (In Russian.) Zool. Muz. Akad. Nauk, St. Petersburg, 13 (1908): 129–220. [Journal title, Annuaire du Musée Zoologique de l'Académie Impériale des Sciences, St. Pétersbourg.]
16. Tables for identification of groups and genera of the plant lice (fam. Aphididae Passerini). (In Russian.) *Ibid.*, 13 (1908): 353–384.
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THE PROTURA OF NORTH AMERICA

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Probably no group of arthropods has in recent years received more attention from students of the evolution of insects than the Protura. Long overlooked by all collectors, this primitive group was first made known to science in 1907 by Silvestri. Immediately they became the

object of intensive study, and due to the researches that have followed, much is now known of their morphology, taxonomy, and world distribution. Something is also known of their habits and a little concerning their biology and life histories, but nothing of their embryology.

The first record of the occurrence of proturans in America was made in 1909 by Silvestri, who reported the collection of specimens of a single species at New York City and Jalapa, Mexico.

The first specimen of the group to be collected in America by an American entomologist was taken in the winter of 1920–21 by H. S. Barber, of the Bureau of Entomology. He found a single living specimen in humus that had been collected some weeks previously by R. C. Shannon at Plummer Island, Maryland.

The present writer began his work (Ewing, 1921a) on these hexapods by describing this species, naming it *Acerentulus barberi*. The collecting of proturans from North America has continued since that date and at present there are in the National Museum, Washington, D. C., representatives from many sections of the United States.

Revisionary work, both in this country and in Europe, has been needed to clarify the status of several species, and to determine the taxonomic significance of certain poorly understood structures. In this contribution an attempt is made toward revising the taxonomy of all species taken in North America and placing on record certain observations concerning their biology and habits.

OCCURRENCE IN NATURE

Although abundant in many moist temperate regions of the world, live proturans probably have never been seen by most entomologists. This doubtless is due in part to their minute size, but also to the fact that they are locally restricted largely to favorable ecological niches. They are particularly creatures of the darkness, are entirely defenseless, and require at all times humid conditions.

The writer has found them most frequently and in greatest diversity between the layers of decaying deciduous leaves, deep down in thick layers of forest litter. In woods where the trees form a complete canopy overhead they are seldom found. But in the more open spaces, particularly those about the edges of our eastern woods they are very commonly found.

Smaller species occur under the thin bark of larger dead twigs, particularly those of brush heaps that have lain for several years, and are slowly undergoing decay. Some species live between the layers of the inner bark of large decaying logs lying on the ground or in a similar situation between the inner bark layers of trunks of large, dead trees. But in such situations they usually are found only when climatic conditions are humid and temperate.

One species occurring in the vicinity of Washington, D. C., lives in sphagnum and under certain conditions may become very abundant. In Europe proturans have been found in moss, and probably occur in moss in this country.

METHODS OF COLLECTING

Proturans may be collected in nature individually by one equipped with a magnifying lens, a small camel's-hair brush, and a few vials of alcohol. And this method has the advantage of allowing the collector

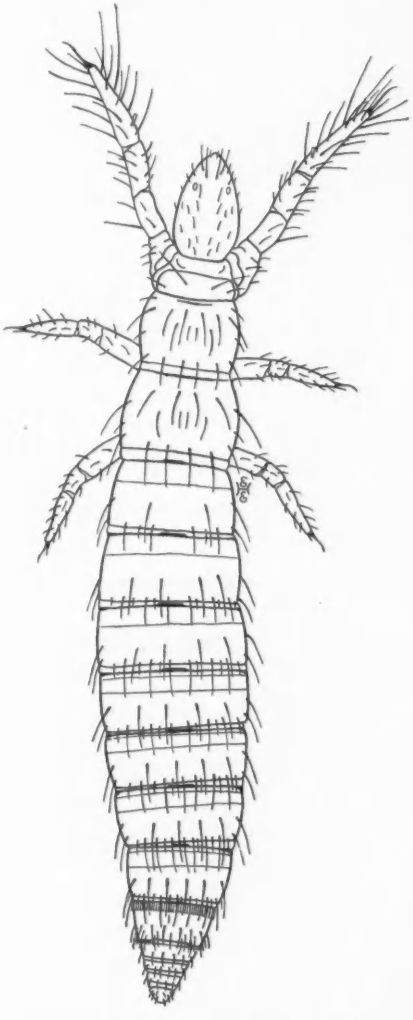


Fig. 1. Dorsal view of a proturan, *Acerentulus barberi barberi* Ewing, × 130.

to observe them alive in their natural habitats. However, because of their minute size and fragile nature, better specimens may be obtained by taking the material in which they occur to the laboratory.

If large numbers of specimens are desired, a Berlese collecting trap is of great service. In the squirming mass obtained by using such a trap at times many proturans will be present. They may be killed in low-grade alcohol (50 to 75 per cent).

One method employed by the writer, which may be called the concentration method, is simple and effective. Material, such as the lower layers of thick, moist, leaf litter, is placed in a large, high, paper bag and brought to the laboratory. The bottom of the bag is set in a pan with moist rags about it, while the top is left open. When the bag, so arranged, is placed in a dry, warm place, particularly in strong light, the proturans will work their way toward the moist bottom. As the top leaves in the bag dry and curl they are removed. Thus in a few days all the proturans will be concentrated in a small amount of leafy material at the bottom of the bag. This material may then be examined over black paper, and the proturans, because of their light color, seen and collected.

The sedimentation method, now employed by some collectors, is of advantage where proturans occur in vegetation such as sphagnum. The sphagnum is placed in a tin can or other vessel to prevent drying. After it is brought to the laboratory, small portions of the material are shaken violently in water in a deep vessel. This washes the proturans off (along with other creatures and dirt particles), and they, being heavier than water, sink to the bottom. At the same time springtails, many mites, and much litter will float on top. The sediment thus obtained is now spread out in a flat glass dish over a black background and examined under magnification. A wealth of small arthropods and worms, as well as some proturans, are thus obtained.

CLEARING AND MOUNTING SPECIMENS

In searching for a proper method and proper agents for clearing and mounting proturans one should keep in mind the nature and delicacy of these minute hexapods, and the particular need for a study of their morphology and taxonomy. Not only are proturans very minute, but they are exceedingly slender and their body walls are very largely membranous. Also in nature the abdominal segments are telescoped to a degree seldom found in any other group of insects. And in addition, the tarsi frequently possess one or more soft, hyalin sense setae, the size, shape, and position of which are of much importance. Because of these facts no single method of clearing and mounting will bring out properly all the important characters. Yet if an investigator is compelled to rely largely upon a single method, staining in acid fuchsin, after clearing in potassium hydroxide and washing in the usual manner, and then mounting in balsam or damar, is preferred. This technique is now being used for several groups of microarthropods. Staining brings out the apodemes, including the tentorium, in a manner superior to all other methods tried by the writer, but the usual treatment with potassium hydroxide, a necessity in the staining process, largely destroys the sense setae on tarsus I.

If certain modifications are made in the usual technique of staining and mounting, the delicate sense setae may be preserved and displayed to advantage. A treatment with very dilute potassium hydroxide will not destroy or distort them, and after such treatment and the subsequent washing they will take a delicate stain with acid fuchsin. If now a good grade of damar is used instead of balsam in mounting, a stained mount can be obtained that will display the sense setae satisfactorily. However, the treatment with very dilute potassium hydroxide in such cases leaves much of the viscera remaining inside the specimen to take the fuchsin stain and obscure the view of certain abdominal structures.

Where damar is used in mounting proturans or other arthropods care should be taken to get a grade that will not discolor with aging. The commercial grades of damar are obtained from several taxonomic groups of trees belonging to many species, growing in several Old World countries, and vary considerably in their physical and chemical properties. The types most suitable for mounting arthropods should be either practically colorless or of a very light golden yellow, after a long period of exposure to the air. Damar that has been kept in stock for many years and is of a light golden yellow color should be safe for use in mounting. The slight amount of coloring in such a sample is invisible in the thin layer held between the coverslip and microscope slide. When balsam is used in mounting, it will, with the passing of years, become of a brownish or amber color and thus largely obscure the details of specimens mounted in it, unless they have received and retained a dark stain before their mounting.

Berlese mixture with a rather low chloral hydrate content can be used to advantage in mounting proturans. This mixture is especially desirable for some of the smaller species and young individuals.

The writer has developed a method of preparation which is a little difficult to apply, but which gives mounts that are excellent for study for a few weeks after preparation. As the mounts age, the refractive index changes slowly, but even old mounts are serviceable. It is here described.

Specimens are first killed in a low grade of alcohol, 50 to 70 per cent. Next they are partially cleared and expanded to a maximum in an aqueous, potassium hydroxide-glycerine solution. About 3 to 5 per cent of this solution should be potassium hydroxide and from 20 to 40 per cent glycerine. The process, which is a slow one, should be watched through a binocular microscope and specimens should be kept submerged. When a maximum extension of the specimens has been obtained and when they are of the desired transparency, they are transferred directly to the special mounting medium on a microscope slide.

This mounting medium is made up as follows:

Water (distilled)	32 cc.
Corn syrup (white "Karo")	50 cc.
Chloral hydrate crystals	10 gms.
Glycerine	5 cc.
Cherry gum (hard, white)	3 gms.

It is practically colorless, and of a very light syrupy consistency, being almost watery. It is used in the same manner as a modified

Berlese mixture, and sets readily at ordinary room temperature. Specimens so mounted should not be oven dried.

Dissections and mounts of parts also have a particular value, especially if an oil immersion lens is to be used, and this is very desirable in studying many of the parts.

POSTEMBRYONIC DEVELOPMENT

The embryonic development of proturans is unknown, and no species has been reared to maturity. Our knowledge of the postembryonic development is based, therefore, largely on a study of individuals of a single species found together in isolated colonies. Most investigators have recognized only four instars in the life history of a single individual. However, Womersley (1927b) states that in *Acerentomon bagnalli* Womersley there are five distinct instars. These in his terminology consist of three larval instars having 9, 10, and 11 abdominal segments, respectively, and two mature instars, "maturus junior" and "maturus major." The last two instars he describes as follows: " 'Major' is, of course, the mature, well-chitinized form with well-developed genital organs. 'Junior' has little chitinization except on the apical abdominal segments and the tips of the fore tarsi; here the apodemes, although unchitinized, are distinctly present as obvious thickenings of the integument, and follow the usual lines of those in the mature form, except that they show no sign of branching. Genital organs are well developed but less chitinized."

Such "junior" forms as Womersley here describes are familiar to anyone who has studied proturans extensively. The present writer regards such as teneral individuals, and as not representing a true instar.

However, in at least one American species, *Eosentomon wheeleri* Silvestri, there exists a form which has the abdomen distinctly 12-segmented but with no visible genital armature. Such individuals not only are smaller and more lightly colored than the fully mature sexual ones, but the abdominal segments are differently proportioned. Furthermore, in one instance an individual of this kind was captured and mounted for examination in its quiescent stage. It contained the newly formed sexually mature adult. It would appear, therefore, that in this species an additional instar is present.

The term larva is more properly applied to the earlier instars of insects having a holometabolous development. Immature proturans should be regarded as nymphs. The first nymph, or the one with a 9-segmented abdomen, should be called the protonymph; the second, the deutonymph; and the third, the tritonymph. For convenience the form with a 12-segmented abdomen but with no genital armature is here designated as the tritonymph +.

SEASONAL HISTORY

Our knowledge of the seasonal history of proturans is most meager. In fact the seasonal history is not known for any one species. However, by identifying the different instars as collected for a single species

coming from States of about the same latitude and by arranging the data thus acquired some idea may be had relative to its seasonal history. This has been done for specimens of *Eosentomon pallidum* Ewing coming from Maryland, Virginia, Pennsylvania, Illinois, and Arkansas. In the following table is recorded the number of individuals of each instar taken in each month of the year.

SEASONAL DISTRIBUTION OF THE DIFFERENT INSTARS OF *Eosentomon pallidum* Ewing

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Protonymphs	.....	1	.....	1	1	4	.....	.....	.....	1	.....	.....
Deutonymphs	.....	.....	.....	.....	2	2	.....	1	.....	.....	.....	.....
Tritonymphs	.....	.....	.....	.....	.....	1	1	1	.....	.....	.....	.....
Males	.....	1	2	1	.....	4	2	1	.....	2	1	.....
Females	.....	2	3	2	1	7	.....	1	3	.....	.....	.....

Although no specimens were taken during the months of December and January and the acquired data give but little indication of the number of generations occurring during the year, they do indicate:

1. That reproduction in this species for the latitudes involved continues for much of the year.
2. That adults of both sexes probably occur throughout the entire year.
3. That reproduction activities are greatest during the spring months.

That reproduction is more active in the spring is further indicated by the fact that in certain species large eggs are found in the oviducts only during the spring or early summer.

TAXONOMIC MORPHOLOGY

The most important structures of proturans for taxonomic study are the segmental appendages and the chitinous parts which largely form the exoskeleton and endoskeleton. The term chitinous is applied to them because they are not destroyed by long treatment in potassium hydroxide and because they take a stain which is very effective for chitin. Most of these structures also are sclerotized.

Head and its sclerites.—In living specimens the head appears to be without sutures. But in dead specimens treated with potassium hydroxide transverse sutures become visible. From two to five of these may be seen in several of our species depending chiefly upon the efficiency of the technique used. These sutures, according to some writers, indicate the primitive segmentation of the head. Because they are hard to demonstrate they have been little used in taxonomy. More easily seen is the clypeo-frontal suture from which arises the clypeo-frontal apodeme, a part of which forms the clypeo-frontal arms of the tentorium (fig. 2, *cat*). The labrum (fig. 2, *l*) in some species is a conspicuous rostrumlike structure projecting from the front of the head. In other species it is vestigial or absent. It usually is separated from the clypeal area by

a suture. Dorsally there extends forward from the posterior margin of the head the sagittal keel (fig. 2, *sk*). Dorsolaterally or laterally near the middle part of the head is a pair of disclike structures somewhat resembling eyes. They are the pseudoculi. Across each usually there extends a chitinous bar and inwardly a small chitinous process.

Ventrally most of the head is covered by extensions downward and inward of the cephalotergites, all of which are united, forming a large cheek lobe on each side. Posteriorly each cheek lobe ends in a pair of flat processes, the gnathopleura.

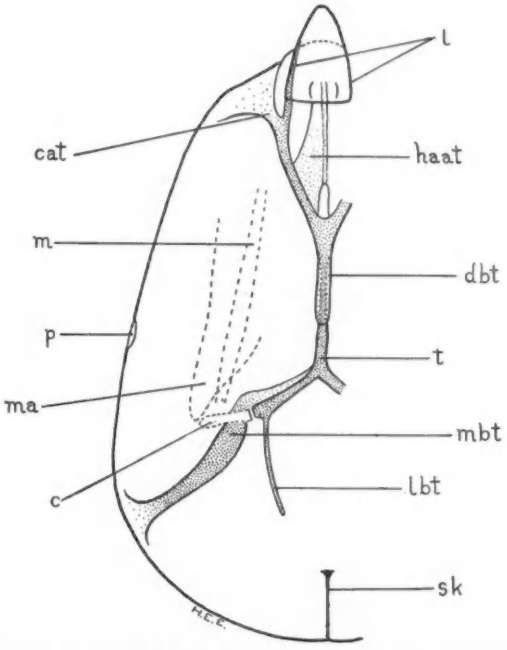


Fig. 2. The sclerotized parts of the inside of the head of *Eosentomon vermiforme* Ewing as seen from above; *c*, cardo; *cat*, clypeo-frontal arm of tentorium; *dbt*, dorsal branch of tentorium; *haat*, hypopharyngeal apodemal arm of tentorium; *l*, labrum; *m*, mandible; *lbt*, labial branch of tentorium; *ma*, maxilla; *mbt*, maxillary branch of tentorium; *p*, pseudoculus; *sk*, sagittal keel; *t*, tentorium.

Mouth parts.—The proturan mouth parts are retracted and similar in their position and general relationships to those of the apterygotan group Entotropha. The mandibles (fig. 2, *m*) are single-lobed, long lances. Each maxilla bears a short, segmented palpus and ends in two lance-like structures, one the single-lobed galea and the other the two-lobed lacinia. The cardo (fig. 2, *c*) is short and rodlike and hinges the stipes to the maxillary branch of the so-called "tentorium."

The labium is much reduced. It possesses a pair of very short, two-segmented palpi, largely surrounded by membranous tissue, and a narrow, transverse, basal sclerite.

Internal skeleton of head.—The internal skeleton of the head consists of the tentorium. It is formed by two pairs of apodemal arms, one of which (fig. 2, *haat*) arises ventrally from the hypopharyngeal region and the other anteriorly from the clypeo-frontal apodeme. These two pairs of arms unite to form the body of the tentorium (fig. 2, *t*), which is a median rod varying much in length and thickness according to the species. Posteriorly the tentorium divides into two primary branches each of which again divides into a lateral maxillary branch (fig. 2, *mbt*) and a posterior labial branch (fig. 2, *lbt*).

External morphology of thorax.—The thorax (fig. 3) exhibits an evident primitive simplicity. It is divided into three freely movable segments, the pro-, meso-, and metathorax. Each of these exhibits a rather well defined dorsum, pleuron, and venter. The prothorax is reduced dorsally and over this reduced portion rests the posterior part of the head. The dorsum of the prothorax is divided into a number of areas by folds of the membranous walls. The pronotum (fig. 3, *pn*) is a rather broad, transverse sclerite. The prosternum (fig. 3, *pst*) is well developed, well sclerotized, and covers almost all the venter. The mesothorax is not reduced. Dorsally it is covered by the mesonotum with its anterior, transverse, marginal apodeme (fig. 3, *tam*), and in the family Eosentomidae an additional median apodeme and a pair of laterally situated spiracles. The mesonotum covers only the anterior part of the dorsum, leaving usually a broad membranous region between it and the meso-metathoracic groove. The pleural region, or pleuron, is largely membranous. From its lower part arises the second leg, about the base of which are two crescentic sclerites representing the subcoxa (fig. 3, *sc II*). The venter is largely covered by the mesosternum (fig. 3, *mst*), which expands laterally posterior to the coxae.

The metathorax is almost an exact replica of the mesothorax, hence needs no description. It is slightly larger than the latter, and its sclerites frequently have slightly different shapes from those of the mesothorax.

Legs.—Legs of the first pair are longer than the others and are held above and in front of the head when a proturan is walking. They are used chiefly as feelers. All legs, however, are similar in their basic structure (fig. 4) and all are composed of the following segments: Coxa, trochanter, femur, tibia, tarsus, and pretarsus. The subcoxa has been transferred to the wall of the thorax, where it is represented by two crescentic plates, the lower of which (fig. 3, *sc*) bears an acetabulum for the reception of the upper articulating condyle of the coxa.

The coxa is very short and subtriangular. It is hinged below to the sternum by means of an articulating condyle. The trochanter is very short, immovably joined to the femur, and hinged to the coxa by means of a dicondylic joint. The femur is the largest segment and may bear distally in its articulating membrane (fig. 4, *ip*) a small sclerite known as the intercalary plate. A study of the leg musculature indicates that this intercalary plate does not represent a vestigial leg segment.

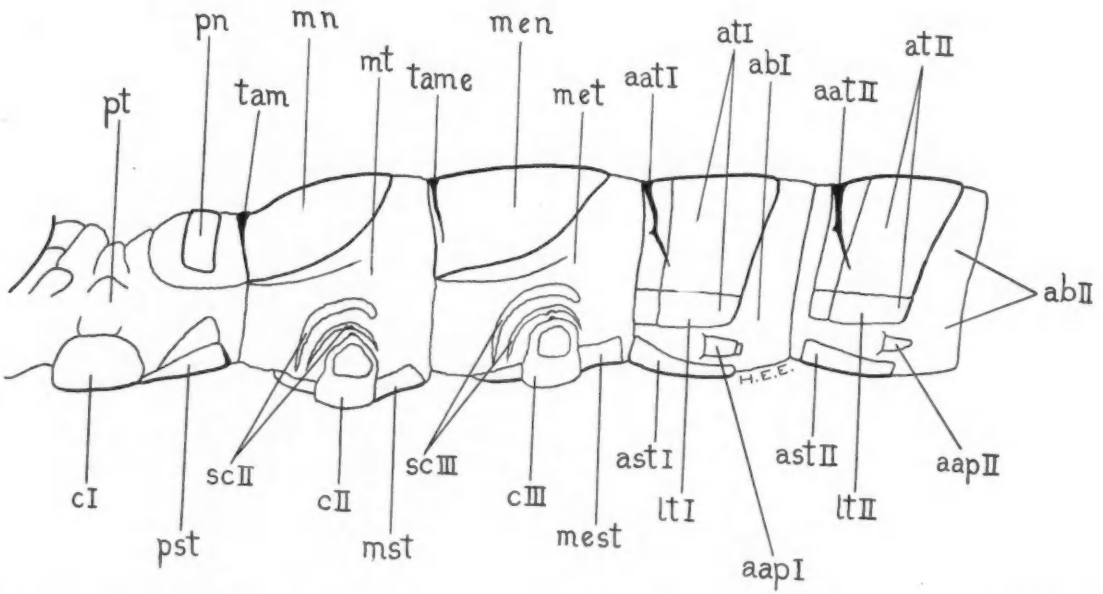


Fig. 3. Lateral view of thorax and first two abdominal segments of *Acerentomon christensoni*, new species, showing sclerites, leg bases, and two abdominal appendages; *aap I*, first abdominal appendage; *aap II*, second abdominal appendage; *aat I*, apodeme of abdominal tergum I; *aat II*, apodeme of abdominal tergum II; *ab I*, abdominal segment I; *ab II*, abdominal segment II; *ast I*, abdominal sternum I; *ast II*, abdominal sternum II; *at I*, abdominal tergum I; *at II*, abdominal tergum II; *c I*, coxa I; *c II*, coxa II; *c III*, coxa III; *lt I*, laterotergite I; *lt II*, laterotergite II; *men*, metanotum; *mest*, metasternum; *met*, metathorax; *mn*, mesonotum; *mst*, mesosternum; *mt*, mesothorax; *pn*, pronotum; *pst*, prosternum; *pt*, prothorax; *sc II*, subcoxa II; *sc III*, subcoxa III; *tam*, transverse apodeme of mesonotum; *tame*, transverse apodeme of metanotum.

The tibia is the first segment beyond the bend (knee) in the leg. Its structure is simple and of little taxonomic importance. The tarsus is longer than the tibia and tapers toward the apex. The tarsis of the first leg bears certain hyaline sense setae (fig. 4, *ass* and *dss*), the number, shape, and position of which are of much taxonomic importance. The pretarsus consists of a dorsal, curved tarsal claw and a ventral, setalike, vestigial mid-claw, or empodium.

Abdominal sclerites.—Mature proturans possess twelve complete abdominal rings or segments. The first seven of these are larger than the others and very similar to one another. The eighth (fig. 1) is more tubular than the others, possesses a longitudinally striated band along

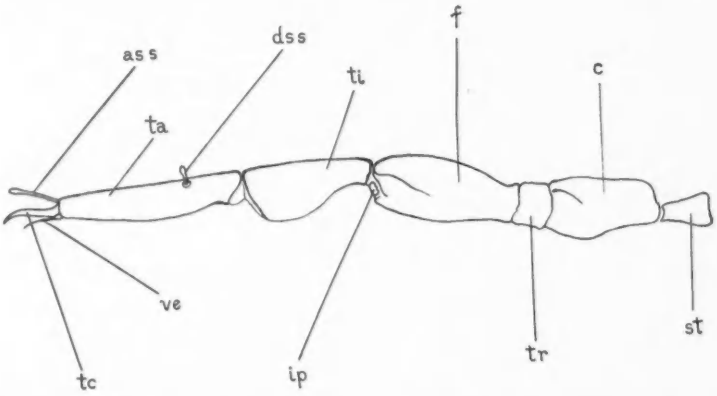


Fig. 4. Anterior view of leg I of *Eosentomon rostratum*, new species, with parts labeled; *ass*, apical sense seta; *c*, coxa; *dss*, dorsal sense seta; *f*, femur; *ip*, intercalary plate; *st*, sternum; *ta*, tarsus; *tc*, tarsal claw; *ti*, tibia; *tr*, trochanter; *ve*, vestigial empodium.

its anterior margin, and may possess a pair of dorsolateral combs on its posterior margin. Segments IX-XI (pl. III, 22), although complete rings, are very short and without special modifications. They are the segments added during postembryonic growth. The last segment (pl. III, 22), the anal, is slightly flattened dorsoventrally.

The pleural area, or pleuron, is greatly reduced in each of the first three abdominal segments and is practically obliterated in the others. This is brought about by the lateral extension of the dorsum. The tergum of a typical abdominal segment (fig. 3, *at I* and *at II*) covers most of the dorsum. It usually bears a transverse apodeme (fig. 3, *aat I* and *aat II*) near the anterior margin, and in some genera there is a longitudinal line or suture on each side which differentiates a laterotergite (fig. 3, *lt I* and *lt II*). Also one to three transverse sutures may be present on a typical abdominal tergum. The typical abdominal sternum (fig. 3, *ast I* and *ast II*) is of approximately the same length as its

accompanying tergum. It usually possesses an anterior transverse apodeme, and transverse sutures corresponding to those present on the adjacent tergum, if this latter sclerite possesses any.

Abdominal appendages.—Each of the first three segments of the abdomen bears a pair of appendages which arise from the pleural areas. The first appendage (fig. 3, *aap I*) is always two-segmented. Its basal segment is much the larger of the two and probably represents the coxa of a vestigial leg, since it is moved by two dorso-ventral muscles (a retractor and a protractor) which appear to be homologous with similar muscles moving the coxa of a thoracic leg. Its distal segment is a short, small ring which ends in an eversible sac. The second and third abdominal appendages may be of the same type as the first, but usually they are very different (fig. 3, *aap II*), being composed of a single, small, subconical, sclerotized segment.

Chaetotaxy of abdomen.—Each segment of the abdomen bears both dorsally and ventrally one or two transverse rows of setae. In addition each of the large or typical abdominal segments may bear a few small marginal or submarginal setae, the supplementary setae, either posterior to or in line with the second transverse row. The setae of the abdomen are of most importance taxonomically. The arrangement of the setae on each of the first seven abdominal segments is essentially the same; hence, in taxonomic practice a description of the chaetotaxy of one of these segments should suffice. Likewise, the setal arrangement for each of the small segments (IX, X, and XI) is usually the same. Segments VIII and XII have rather distinctive chaetotaxy.

The setae of one of the typical large abdominal segments are arranged in either one or two transverse rows. Where there is a single dorsal row, it usually, if not always, is composed of subequal setae about evenly spaced in the row. Usually two dorsal and two ventral transverse rows of setae are present. In such cases the first dorsal row is made up of similar setae, of which there may be two, four, six, or eight. The posterior dorsal row may be composed either of exclusively large setae or of large and minute setae (supplementary setae). When this row consists of only large setae, they are similar in size and arrangement to those of the first row. When supplementary setae are present, the position of these and of the accompanying large setae are of taxonomic importance.

Ventrally the setae of the two transverse rows on a large abdominal segment have a similar disposition to those of the dorsal rows except that a median seta frequently is present in either row, resulting in an odd number of setae in a row.

The chaetotaxy of the eighth abdominal segment usually differs from that of each of the first seven segments in that the first transverse row may be reduced or absent. Only a single transverse row, usually of similar setae, is present (fig. 1) on each of the small segments (IX, X, and XI). The anal segment has a single, irregular, transverse row of setae, which is either marginal of submarginal.

HABITS AND PHYSIOLOGICAL FUNCTIONS

Being creatures of minute, dark, damp chinks and crevices, proturans are hard to observe in nature without violently disturbing their natural habitat. However, small observation cells, which simulate many of the natural environmental conditions, may be employed to study them in the laboratory.

Observation cells.—The observation cells employed by the writer were made and used previously by H. S. Barber of the Bureau of Entomology in his studies on the biology of certain small beetles. He made a cell of this type in the following manner:

First, a small, paraffined tin box was obtained. Next, a piece of glass, large enough to cover much of the central area of the lid of the box, was fastened to the under surface of the latter. Then plaster of paris was poured into the bottom of the box, the lid was put in place, and the whole was inverted for setting. This inverting process is necessary in order to prevent air bubbles collecting under the glass as the plaster sets.

After the setting of the plaster the piece of impressed glass is removed and one or more small cells are made by boring into the plaster with a half-inch metal drill.

An observation cell made in this manner retains the proper moisture because of the porous nature of the plaster. Water condensation on the sides of the cell is also avoided because of the same property of the plaster. The lid is kept on the box at all times except during observation, so as to exclude the light and prevent excessive evaporation.

When it is desired to observe the specimens in the cell, the whole box is placed on the stage of a binocular microscope in rather subdued light, then the tin lid is removed. The glass cover under the lid, while retaining the live specimens and the humid atmosphere of the cell, permits observation of the inside of the latter.

Food.—The actions of free-living proturans are suggestive of predatory habits. They move about slowly and stealthily, with the long, terminally clawed, front legs held high over the head as though poised for instant service against a victim. Yet observations by the writer over many years upon hundreds of individuals in nature and scores in captivity have failed to reveal a single instance of predation. It appears logical to assume, therefore, that they are not predaceous and that the front legs are held in such a manner in order that they may function as feelers. Furthermore, the absence of antennae in these minute arthropods creates a need for the assumption of their function by some other organs.

Since some species of Protura are found in situations where there are few, if any, victims present upon which to feed and where but little animal matter of any kind occurs, it appeared desirable to see if they could be kept in captivity with only vegetable matter as food. Hence some experiments were conducted to see if they would live on dead-leaf material.

On February 21, 47 live proturans were placed in a plaster of paris breeding cell with about a half-dozen discs made from moist dead,

leaves. No live creature of any kind was observed on these pieces of dead leaves, and if any dead animal matter was present it was exceedingly small in amount. On March 4 the cell was opened and its contents were noted. Twenty-three of the 47 individuals were not found, being overlooked or having escaped, 3 were dead, 1 either quiescent or dead, and 20 alive and in good condition. This observation might possibly be interpreted as indicating that the proturans were feeding on the decaying leaf tissue with which they were provided.

On March 4, 19 individuals were given only undecayed dead-leaf material as food. When examined the next day, only a single proturan was found among the leaf discs and it was dead. Outside the cell were found two live and one dead individuals. The proturans evidently had left the dead but undecayed leaf discs and had scattered.

On March 5, five active individuals were confined in a cell with only a small piece (about one-fourth of a square centimeter) of a decayed leaf for food. This piece included a part of the epidermis of the leaf after it had been loosened by decay. It was carefully examined and found free of all animal matter. Observations through the glass top of the cell were made March 6 and for many days following. On March 9 one of the individuals (an adult female of *Acerentulus tenuiceps* Ewing) was found dead. Another individual (an adult male of *Eosentomon vermiforme* Ewing) was found dead on March 19. On April 7 the three remaining individuals were active and apparently in good condition. The third death, that of an adult female of *Acerentulus tenuiceps* Ewing, occurred on April 8; and the fourth, that of an adult female of *Acerentulus tenuiceps* Ewing, on April 13. The remaining live individual was last seen on April 17. It is not known whether it escaped on this day. Repeated daily observations until April 28 did not reveal its whereabouts.

These observations might be interpreted as indicating that proturans will feed for many days on leaf tissue that is in an advanced state of decay, yet of course during this last experiment they may have lived for these many days without feeding.

Contents of mesenteron.—Repeated observations of the mesenteron have failed to reveal the presence of solid particles of food. During the feeding experiment just described, when certain individuals were given as food only a small piece of a moist decaying leaf, changes in the contents of the midgut were noticed. While these changes were probably correlated with the digestion of liquid food, no proper significance could be attached to them.

Peristaltic movements.—Peristaltic movements of the midgut were frequently observed in the proturans kept in observation cells. When individuals are active these movements are more pronounced than when they are at rest. The movement frequently starts near the middle of the mesenteron, then extends backward. Reversing from the extreme posterior aspect of the mesenteron the movement extends forward so as to involve this structure in its entirety and may again reverse at the anterior end and passing backward die out somewhere along the course of the midgut. This movement, being somewhat of a churning type, probably causes a mixing of the contents of the midgut.

Pulsating movements of abdomen.—Respiration in most insects is made possible by the rhythmic contraction and expansion of the abdomen. In many of them special expiratory muscles passing between the tergum and sternum of each abdominal segment forces the air out through the spiracles; while expansion due to the elasticity of the abdominal wall, as a rule, is responsible for the inspiration of fresh air.

Proturans, although most of them are without tracheae, show pulsating movements of the abdomen, but of a type different from that of other insects. This pulsation is due to deep telescoping movements of the last large abdominal segment, the eighth, into the seventh. The eighth segment has its base somewhat expanded (plate III, 22) and that part which telescopes into the seventh is bare and longitudinally striated. When this eighth segment pulsates the abdominal segments posterior to it, all of which are small (plate III, 22), move with it as one. I have observed this pulsatory movement of the posterior part of the abdomen in the following species:

Eosentomon pallidum Ewing.
Acerentomon conurus Ewing.
Microentomon minutum Ewing.

It was timed in a species of *Acerentulus*, the number of pulsations being 54 per minute. Only conjecture is held relative to the possible significance of this rhythmic movement. In order to bring about inspiration and expiration of air not only would the presence of tracheae be necessary but probably also that of air sacs.

That there is a possibility that these pulsating movements may aid in the mixing or circulating of the blood should not be overlooked. Berlese (1909) mentioned a "*cordone pericardico*" said to be present in certain proturans. It was described as a long tube or sinus of small and uniform diameter lying along the mid-dorsal line. Although in no true sense a heart, this dorsal sinus, because of its elasticity, might in a passive way aid the circulation of the blood. Possibly the deep telescoping action of the eighth abdominal segment into the seventh, as takes place during the pulsating movements just described, would force a certain amount of blood into or through it and in this way aid very materially in the circulation of the blood.

But Aubertot (1939) has demonstrated the presence of a true heart in *Acerentomon*. It is described as a long tube extending from the second thoracic to the seventh abdominal segment. In each of the first seven abdominal segments it is dilated into a contractile chamber provided with a pair of ostia. Each contractile chamber lies in the triangular space between the inner borders of the dorsal longitudinal muscle bundles and the apodeme of the following abdominal segment. If Aubertot's observations are correct and a true heart exists in most species of the Protura, one could hardly suspect the described pulsating movements to have any direct connection with the circulation of the blood.

Flexibility of the abdomen.—Of all the hexapods the Protura alone possess twelve complete abdominal rings, or segments. These segments are attached to each other by broad membranous bands which consti-

tute a part of the body wall. Because of this arrangement the abdomen is capable of either great contraction, due to the telescoping of the segments, or great extension, due to the presence of the many broad connecting membranous bands.

Individuals at rest frequently have the abdomen so contracted that they are but little more than half of their extended length. Yet when active they may greatly extend the abdomen or curl it over the back, holding the tip high in the air.

Copulation.—This was observed only once and as follows: As the last piece of a decayed leaf was being lifted from an observation cell several active proturans were observed left behind in the bottom of the same. One of these was running about with another as a rider. The rider had the abdomen highly arched and curved downward and forward, its tip being in contact with the genital area of the carrier.

In this position the two were removed to a new cell. But soon afterward the rider became detached and upon falling off did not run away. When killed in alcohol it showed the maximum extension of the genitalia, being a male. The specimen was mounted in balsam on a microscope slide, and proved to belong to *Acerentulus oculatus* Ewing.

Egg development.—Berlese (1909) has described the female reproductive system in the Protura. The internal female organs consist of a pair of laterally situated gonads, each being a single egg tube. The two tubes, which posteriorly become oviducts, unite just before entering the base of the genital armature. Berlese noted that in specimens which he studied only a single egg reached maturity at a time, that it was very large, oblong-oval in shape, and never showed development of the embryo.

In general this condition is that which the present writer has observed. However, in *Eosentomon vermiforme* Ewing six eggs apparently are simultaneously developed. These eggs (if indeed they are eggs) apparently develop from three pairs of egg tubes located for the most part in the third abdominal segment. The eggs (?) at first are almost spherical, but assume more and more the typical oblong-oval shape as development continues.

PHYLOGENY

When Silvestri (1907) made known to science the existence of these minute arthropods he was acquainted with only a single species, *Acerentomon doderoi* Silvestri. Yet his study of the external morphology of this single species was so thorough that when he proposed for its reception a new order of Insecta, the Protura, he dealt with many of the basic morphological facts concerning them. He did not hesitate in placing his new order in the Apterygota, and regarded the Protura as having a superior status to that of the Thysanura and the Collembola. He considered as primitive particularly the position of the genital opening and the nature of the anal segment, but regarded the absence of the antennae as a secondary development.

Berlese (1908), following the discovery of anamorphosis in the proturans and a study of their internal anatomy, decided that they did not belong to Insecta, but were related basically to the myriapods in

their method of postembryonic development. In his monograph (Berlese, 1909) he gave them the name of Myrientomata, indicative of their relationships both to Myriapoda and to Insecta. In the preparation of this monograph Berlese had a wealth of material representing two families, three genera, and ten species. He applied a very accurate technique in his study of their internal morphology and histology and gave to us in his monograph a monumental work, probably the most important and the most accurate contribution that yet has appeared dealing with these primitive arthropods.

Börner (1910) regarded the proturans as insects, pointing out in particular their affinities with the Collembola. He divided the Entotropha into the three orders, Diplura, Protura, and Collembola.

Prell (1911, 1913), further emphasizing the anamorphosis (which he referred to as hemianamorphosis) exhibited in the postembryonic development of the Protura, divided all Insects into two subclasses, the Anamerentoma (Protura) and the Holomerentoma (the remainder of the insects). He devoted his studies particularly to the sclerotized parts and the tracheal system, and described an elaborate system of small thoracic sclerites. His results relative to the latter have not been sufficiently verified.

Crampton (1916), in his very interesting paper on the relationships of apterygotan insects, divided the Apterygota first into a non-styli-bearing group, the Astyligera, and a styli-bearing group, the Eustyligera. The former group he further divided into three groups: 1, Eosentomoides (Protura); 2, Entomobryoides (Euarthrura, or springtails with abdominal segments usually free and distinct); 3, Sminthuroides (Synarthrura, or springtails in which the abdominal segments are anchylosed). The latter group, the Eustyligera, includes two sections: Rhabduradelphia (Campodeoides, Projapygoides, and Japygoides) and Thysanuradelphia (Dasyleptoides, Machiloides, and Lepismatoides).

Thus he not only would admit the proturans to an undoubted place among the insects, but would ally them most closely with certain of the more generalized springtails.

In a later paper Crampton (1919) pointed out that the Protura, as well as the remainder of the Apterygota, have much in common with the Myriapoda, yet he stated that the Protura "are quite closely related to such other Apterygota as *Tomocerus*."

Tuxen (1931) regarded the Protura as being related chiefly to the Crustacea on the one hand and the Insecta (through the Apterygota) on the other. He held that the so-called palpus and galea of the proturan maxilla represent the crustacean maxillula.

Imms (1936), in his recent treatise on "The Ancestry of Insects," gives the Protura, as well as the Collembola, a position separated from Insecta proper. He states that, "The Collembola are even more remote from the main line of insect evolution than Proturans." He further points out that the Collembola are differentiated from all insects in never possessing more than nine postcephalic segments at any stage of their ontogeny, in having the germarium of the gonads lateral instead of apical, in lacking Malpighian tubes, and in exhibiting total cleavage during their embryonic development.

Because of this wide departure of proturans and collembolans in certain important respects from other insects he divides Insecta into three subclasses as follows:

"Subclass I. Oligoentomata: Collembola.
" II. Myrientomata: Protura.
" III. Euentomata: Thysanura and Pterygota."

All students of the Protura appear to be agreed that they are generalized arthropods with basic characters some of which are primitive and some of which, though simple, have been secondarily acquired. Probably the chief reason for such a diversity of opinion relative to their zoological position is that a proper evaluation and interpretation of the basic characters can not be made. However, by way of a summary some of the more important characters of the Protura from the standpoint of their phylogeny may be mentioned.

In the first list should be given those simple characters that are rather obviously acquired secondarily. I say obviously because in other groups of arthropods these same types of simplicity are observed and under conditions which unmistakably point to their secondary acquisition. They are: The absence of antennae; the absence of eyes; minute size; the absence of paired appendages on those abdominal segments posterior to the third; and the reduction or loss of the tracheal system.

Also apparently of a secondary nature is the type of gonads present in the Protura. Each gonad consists typically of a single egg tube or sperm tube. In one American species, *Eosentomon vermiforme* Ewing, according to observations of the present writer (which, however, need further confirmation) there are three pairs of egg tubes. If this interpretation is correct, it means that the usual condition is to be regarded as secondary.

The pseudoculi have been regarded as homologous with the organs of Tömösvary, the postantennal organs of collembolans, or the pseudoculi of pauropods, but according to Tuxen (1931) they are the rudimentary antennae. While this last homology possibly is indicated by their position and innervation, the musculature does not indicate their homology with the antennae. A single muscle from the tentorium attaches to the margin of the epicranium just in front of the operculum of the pseudoculus, but, as pointed out by Berlese (1909), it has as its function the elevation of the elastic tentorium rather than the moving of the operculum. Furthermore, the structure of the pseudoculi is foreign to that of any known vestigial arthropod appendage.

Then there are those basic characters that appear to indicate relationships with other groups of arthropods. At least two of these must be regarded as myriapodan in nature. They are the postembryonic development in the proturans by means of anamorphosis and the possession of a pair of appendages (legs?) on each of the first three abdominal segments.

A character which should be regarded as generalized, yet concerning the interpretation of which there is doubt, is the presence in proturans of large, dorsal, abdominal glands, which not only possess pairs of segmentally arranged openings, but are themselves segmentally lobed.

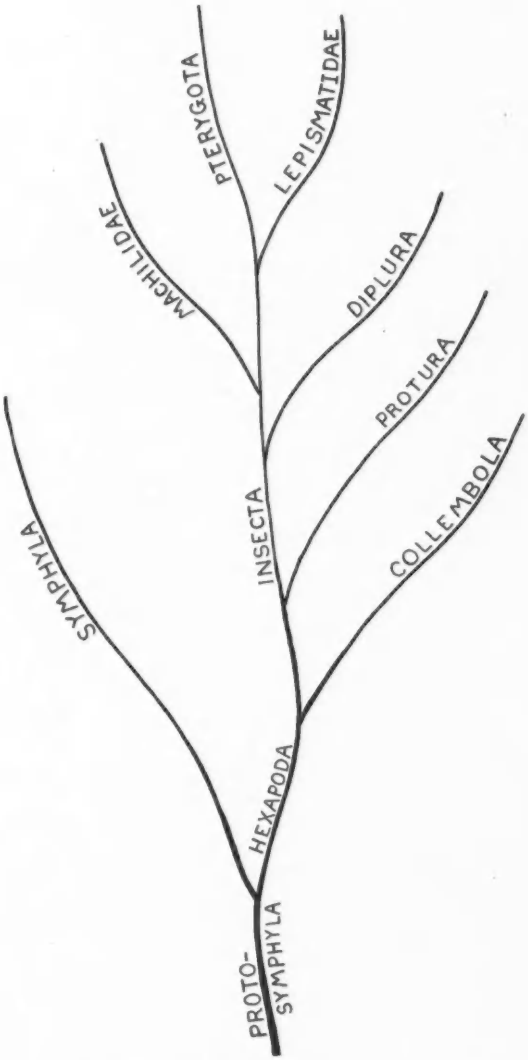


Fig. 5. Diagram illustrating the suggested origin of the most primitive groups of hexapods.

They were first described by Berlese (1909). These glands in life discharge a thick, viscous secretion, chiefly through the openings at the posterior margin of the eighth abdominal tergum. Börner (1910) compared them with a pair of glands found in the fourth abdominal segment of certain collembolans. The viscous secretion of these abdominal glands suggests the secretion of the anal glands of symphylids. The latter is discharged at the tips of the cerci. That the anal glands of symphylids probably are homologous with the anal glands in certain apterygotans of the family Japygidae appears plausible. And possibly the anal glands of both symphylids and certain apterygotans represent the simplified and modified abdominal glands found in proturans. But concerning this there is at present no convincing evidence.

In common with insects, proturans have the same number of body segments, the same sort of mouth parts, three pairs of thoracic legs of the insectan type, and gonads of the insectan type in that the germarium is apical in position.

According to Prell (1913) and Tuxen (1931) the tentorium in the Protura is developed from hypopharyngeal apodemes into a ventral rod-like structure which is primarily and secondarily forked. The present writer has examined the tentorium of several species of American proturans and finds that apodemal arms do arise ventrally from the hypopharyngeal region of the head and unite, thus helping form the tentorium proper, yet the most conspicuous of the anterior apodemes usually are those that arise from the clypeofrontal suture. These apodemes pass backward above the mandibles, as shown by Berlese (1909), and unite to help form the body of the tentorium. The anterior ventral apodemal arms, therefore, probably are homologous with similar structures in Myriapoda and with the tentorial sclerotizations of Diplura and Collembola, which, according to Snodgrass (1938), take the form of long internal ridges that "diverge posteriorly from the base of the hypopharynx as sclerotic linear inflections of the membranous integument along the folds between the gnathal pouches and the inner surface of the labium."

The anterior dorsal apodemal arms that arise as the clypeofrontal apodemes, and uniting help form the body of the tentorium, apparently represent the anterior arms of the tentorium of Pterygota. Thus in the Protura possibly there is exhibited a transformation from a primitive type of tentorium as is found in Myriapoda and certain apterygotan insects, to a simplified type homologous with that of the anterior arms of the tentorium of pterygotan insects.

Proturans have so many basic characters in common with insects that many entomologists have regarded them as such. Whether or not they, together with the Collembola, are to be regarded as true insects obviously depends upon the definition which is adopted for Insects. That proturans and collembolans are true hexapods is more readily apparent. In each group it is the same three body segments that are differentiated for the purpose of locomotion, the same antethoracic segments that have been formed into the head, and the same cephalic appendages that have been modified with reference to food-getting and its related functions. If it is granted that this basic division of the

body into homologous cephalic and thoracic regions is the most important of all characters under consideration, then most certainly proturans are insects. However, could they not be regarded as true hexapods and yet not true insects? If so a classification as follows could be adopted:

Superclass Hexapoda.
- Class I. Collembola.
- Class II. Protura.
- Class III. Insecta.
  - Subclass I. Thysanura.
  - Subclass II. Pterygota.

The present writer would not derive Hexapoda directly from Symphyla but from symphylid-like ancestors. The Collembola and Protura, being decidedly isolated groups, could hardly be of the same origin as their related endognathous Diplura. The suggested origins of the major groups of Hexapoda are indicated in the accompanying diagram (fig. 5).

CLASSIFICATION

Berlese (1909) was the first to classify the Protura. The ten species known to him were placed in two families, three genera, and two subgenera. The family Acerentomidae, established by Silvestri (1907) for a single genus and species, was separated from a proposed new family, Eosentomidae, on the absence of stigmata and tracheae. It was divided into two genera, *Acerentomon* Silvestri and *Acerentulus* Berlese. The former genus was described as having a long, styliform labrum, the lacinia formed into two long stylets, and the labial palpus composed of four distinct segments. The latter genus was described as having the labrum not produced into a pointed process, the lacinia formed into two short stylets, and the labial palpus composed of three distinct segments. The genus *Acerentulus* was divided into two subgenera. The typical one included five species, in which the transverse dorsal apodemes are strongly incurved; while the new subgenus, *Acerella*, included but a single species, in which the transverse dorsal apodemes are but slightly incurved.

The other family recognized by Berlese, Eosentomidae, included only the genus *Eosentomon* Berlese. Three species of this genus were known to him. Since 1909 a considerable number of new species have been added to *Eosentomon*, yet the genus remains undivided and has been considered by nearly all workers as alone constituting the family Eosentomidae.

During the same year that Berlese published his classification of the Protura two new genera were proposed, *Proturentomon* by Silvestri (1909) and *Protaperon* by Schepotieff (1909). The first mentioned was long considered as a synonym of *Acerentulus*, but has been rightly reinstated by Bagnall (1936). The second was based upon a species which was supposed to have antennae. A later examination of a type specimen showed that the antennae were absent, and that the species should have been considered a representative of the genus *Eosentomon*.

Following the year 1909, a notable one for basic research on the Protura, several years elapsed before any new genera were proposed. When the present writer (Ewing, 1921b) described several new species of American proturans, three new genera were proposed, but no changes suggested in the basic classification of Berlese. However, at this time an unusual species was brought to light, it being the type and only species of a proposed new genus, *Protentomon*. Concerning this species, *P. transitans* Ewing, the writer stated, "This species . . . is by far the most important taxonomically of any of the American forms thus far discovered. This is because it unites the two quite distinctive families of the Protura that have been recognized in the past; the Eosentomidae, which have tracheae, and the Acerentomidae, which do not." The genus *Protentomon* has figured prominently since its establishment in the taxonomy of the Protura.

Womersley (1927a) divided the family Acerentomidae into two subfamilies, the Acerentominae, including the genera *Acerentomon* Silvestri and *Acerentulus* Berlese, and the Meroentominae, including the genus *Protentomon* Ewing (for which he proposed in error the new name of *Meroentomon*) and a new genus *Paraentomon*. Members of the Acerentominae were separated from those of the Meroentominae, since in the former only the abdominal appendages of the first pair are two-segmented, while in the members of the latter subfamily the abdominal appendages of both the first and second pairs are two-segmented.

Mills (1932) pointed out that the change of the name *Protentomon* Ewing to *Meroentomon* by Womersley and the utilization of the latter name for the proposed new subfamily was not tenable. Therefore, he proposed the new subfamily Protentomoninae to take the place of Meroentomoninae Womersley.

Womersley (1932) reinstated, entirely without justification, the family Protapteridae Börner based on the genus *Protapteron* Schepotieff (1909). But Rimsky-Korsakow (1911) had re-examined a type specimen of the type species, *P. indicum* Schopotieff, and found that it was a typical species of *Eosentomon*. The family Acerentomidae was again divided into two subfamilies, Acerentominae and Meroentominae, both of which had been previously established by Womersley. The remaining family, Eosentomidae Berlese, included but the single genus *Eosentomon* Berlese.

Bagnall (1936) reinstated the genus *Proturentomon* Silvestri and claimed that *Protentomon* Ewing, *Meroentomon* Womersley, and *Paraentomon* Womersley were only synonyms of Silversti's genus. He even synonymized the genotype of *Paraentomon* with that of *Proturentomon*.

The present writer (Ewing, 1936), in his synopsis of the genera of Protura, divided the whole order into three families, erecting the new family Protentomidae for members which are separated from the formerly recognized family Acerentomidae in having the abdominal terga without transverse grooves and laterotergites, typical abdominal segments with but a single transverse row of dorsal setae, and segment VIII of abdomen without pectines or combs. In this new family were placed three genera, *Protentomon* Ewing, *Proturentomon* Silvestri, and

Microentomon Ewing. Three genera were likewise placed in Acerentomidae, *sensu stricto*—*Acerentomon* Silvestri, *Acerentulus* Berlese, and *Acerentuloides* Ewing.

Womersley (1939) proposed the subfamily name Proturentominae to take the place of Protentominae Mills. Mills' name, however, has priority, and there is no justification for the suggested change.

A classification of the order is here given which represents only a slight modification of the one published by the writer in 1936.

A CLASSIFICATION, IN KEY FORM, OF THE GENERA AND HIGHER GROUPS OF PROTURA

A. Tracheae present, opening through two pairs of spiracles, one on mesothorax and one on metathorax; all vestigial abdominal appendages 2-segmented; segment VIII of abdomen without pectines,
EOSENTOMIDAE Berlese
Contains but a single genus.....**Eosentomon** Berlese
Syn.: **Protapteron** Schepotieff

AA. Tracheae and spiracles absent; vestigial abdominal appendage III, 1-segmented; segment VIII of abdomen usually with a pair of pectines.

B. Abdominal terga without transverse sutures and laterotergites; typical abdominal segments with a single, complete, transverse row of dorsal setae; pectines of abdominal segment VIII reduced or absent,
PROTENTOMIDAE Ewing

C. Vestigial abdominal appendage II, 2-segmented; segment VIII of abdomen with pectines; front tarsi with sensory setae,
PROTENTOMINAE Mills
Syn.: **MEROENTOMINAE** Womersley
PROTURENTOMINAE Womersley

D. Dorsal abdominal apodemes distinct, each branched laterally; labrum distinct.....**Proturentomon** Silvestri
Syn.: **Paraentomon** Womersley

DD. Dorsal abdominal apodemes absent, indistinct or inconspicuous, unbranched laterally; labrum apparently absent.....**Protentomon** Ewing.
Syn.: **Meroentomon** Womersley

CC. Vestigial abdominal appendage II, 1-segmented; segment VIII of abdomen without pectines,
MICROENTOMINAE, new subfamily
Contains but a single genus.....**Microentomon** Ewing

BB. Typical abdominal terga each with 1 to 3 transverse sutures and a pair of laterotergites; typical abdominal segments with two complete transverse rows of dorsal setae; pectines on abdominal segment VIII not reduced.....**ACERENTOMIDAE** Berlese

C. Labrum (rostrum) usually long, narrow, and conspicuous,
Acerentomon Silvestri

CC. Labrum very short and minute or absent.....**Acerentulus** Berlese
Syn.: **Acerella** Berlese
Acerentuloides Ewing

ORDER **PROTURA** SILVESTRI

Primitive, wingless hexapods with a long, fusiform, slightly depressed body divided into an insectan head, thorax, and abdomen.

Head small, subconical, with indistinct transverse sutures on dorsum, and extending backward above front part of prothorax. Eyes absent, but specialized structures resembling eyes, called pseudoculi, present. Antennae absent. Mouth parts typically insectan, retracted. Mandibles styliform. Maxilla with filiform palpus, bladelike galea, and two-lobed, styliform lacinia. Labium much reduced, with short, cylindrical, one-, to two-segmented palpi.

Thorax very distinct. Prothorax reduced dorsally, with small pronotum; pleural area broken up into smaller areas by folds of membranous integument; venter largely covered by well sclerotized prosternum. Meso-, and metathorax subequal, each with large notum, with or without a pair of dorsolateral stigmata.

Legs similar, front pair longer than others and seldom used in walking, each with five segments, not counting vestigial and immobile subcoxa or the pretarsus. They are: Coxa, trochanter, femur, tibia and tarsus. Pretarsus consisting of a single, simple, curved claw and, a ventrally situated, setalike, frequently vestigial empodium.

Abdomen with twelve complete rings (segments) in adults but with only nine rings in first nymphal instar. A single ring is added at time of each molt by a division of terminal segment into two segments. A single pair of two-segmented, vestigial appendages present on first abdominal segment and a pair of either one-, or two-segmented appendages on the second and third abdominal segments. Anus terminal, between tergum XII and sternum XII. Genital opening between sternum XI and sternum XII. Cerci absent.

Contains three families: **Eosentomidae** Berlese, **Protentomidae** Ewing, and **Acerentomidae** Silvestri.

FAMILY **EOSENTOMIDAE** BERLESE

1909. Eosentomidae Berlese, Redia, vol. 6, p. 48; 1927, Womersley, Ent. Mon. Mag., vol. 63, p. 146; 1930, Ionesco, Acad. Roumaine, Bul. Sect. Sci., 13th Ann., no. 1–2, p. 7; 1931, Tuxen, Zeitsch. f. Morph. n. Ökol. d. Tiere, vol. 22, Heft 4, p. 710; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 126; 1932, Womersley, Proc. Linn. Soc. New South Wales, vol. 57, pts. 1–2, nos. 239–240, p. 71; 1936, Ewing, Proc. Biol. Soc. Wash., vol. 49, p. 164.

Tracheae present and opening through two pairs of spiracles, one situated near the lateral margins of the mesonotum and the other in a similar position on the metanotum. Thorax sharply differentiated from abdomen. Last four abdominal segments markedly smaller than the others. Typical abdominal terga without transverse sutures and laterotergites. Each vestigial abdominal appendage 2-segmented, having a large, cylindrical, basal segment and a very short, ringlike, terminal one. Segment VIII of abdomen without a pair of pectines. Front legs much longer than others; tarsus I long, with specialized sensory setae.

Only genus: *Eosentomon* Berlese.

The family Eosentomidae is strikingly different from the other two families in having tracheae. This character is to be regarded as a primitive one, as is the presence of three pairs of two-segmented vestigial abdominal appendages. Compared with the other two families of proturans the family Eosentomidae shows specialization in having the thorax, as well as the last four abdominal segments, more sharply differentiated.

Genus **Eosentomon** Berlese

1908. *Eosentomon* Berlese, Redia, vol. 5, p. 18; 1909, Berlese, Redia, vol. 6, p. 57; 1921, Ewing, Proc. Ent. Soc. Wash., vol. 23, no. 9, p. 194; 1927, Womersley, Ent. Mon. Mag., vol. 63, p. 146; 1930, Ionesco, Acad. Roumaine, Bul. Sect. Sci., 13th Ann., no. 1–2, p. 7; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 710; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 126; 1932, Womersley, Proc. Linn. Soc. New South Wales, vol. 57, pts. 1–2, nos. 239–240, p. 71; 1936, Ewing, Proc. Biol. Soc. Wash., vol. 49, p. 164.

1909. *Protapteron* Schepotieff, Zool. Jahrb., Abt. b. Syst. Geog. u. Biol., vol. 28, Heft 2, p. 212–138.

Mesonotum and metanotum each usually with an anterior transverse apodeme and a sagittal or median apodeme. Typical abdominal segments with two transverse rows of dorsal and ventral setae. Leg II smaller than leg III. Tarsus III frequently with a conspicuous, subterminal, dorsal spine.

Type species.—Eosentomon transitorum Berlese.

Remarks.—No genus in the whole order Protura is so well defined or so homogeneous as this one.

KEY TO NORTH AMERICAN SPECIES OF EOSENTOMON

1. Head with a long, narrow, beaklike labrum, which is about one-third as long as the remainder of the head. A large species..... **rostratum**

   Head either without visible labrum or with a short labrum broadened at its base which is never more than one-fourth as long as the remainder of the head.....2

2. Labrum distinct; all body segments yellow.....3

   Labrum indistinct or absent; some of body segments may be whitish.....4

3. Length when only slightly extended over 1.20 mm.; pseudoculi lateral; labrum conspicuous; lateral margins of head appearing almost straight when viewed from above; median tergal apodeme of metathorax not ending posteriorly in a transverse bar..... **vermiforme**

   Length when only slightly extended about 1.0 mm.; pseudoculi indistinct; labrum short; lateral margins of head usually appearing curved when viewed from above; median tergal apodeme of metathorax ending posteriorly in a transverse, seta-bearing bar..... **wheeleri**

4. Dorsal setae of tarsus I not arising from tubercles; claw of tarsus I but little, if at all, curved near base; dorsal spine of tarsus III distinctly spinelike.....5

   Dorsal setae of tarsus I each arising from a tubercle; claw of tarsus I shorter than usual and curved toward base; dorsal spine of tarsus III but little more than a stout seta..... **yosemitensis**

5. Length with segments slightly extended over 0.80 mm.; dorsal setae of body of usual length; longest spiracular seta about one-half as long as width of thorax..... **pallidum**

   Length with segments slightly extended about 0.60 mm.; dorsal setae of body very short; longest spiracular seta only about one-third as long as width of thorax..... **pusillum**

Eosentomon rostratum, new species

(Text fig. 4; plate I, fig. 1)

A large species, with plates of each body segment well sclerotized and pigmented. Head long, converging lateral margins almost straight. Labrum long, slender, conspicuous, in length equal to one-third the remainder of the head. Pseudoculi small, each situated at middle of lateral margin. Tentorium well developed; body of tentorium equal in length to about one-third that of head; maxillary branch very conspicuous, broader at base than base of cardo, broadly branched apically; labial branch small, inconspicuous, straight, extending less than one-half distance to posterior margin of head.

Thorax very distinct. Prothorax with about one-half of dorsal area concealed from above by posterior part of head; pronotum entire, with two pairs of subequal setae situated dorsolaterally along posterior margin. Mesothorax as broad as long; mesonotum with inconspicuous transverse apodeme and faint median apodeme ending posteriorly in a broad transverse bar, the latter bearing a seta at each end; spiracle conspicuous; spiracular setae of usual arrangement, the posterior seta slightly longer than the anterior; mesosternum divided into a broad, triangular, anterior eusternum and a smaller, posterior sternellum. Metathorax very similar to mesothorax but transverse apodeme more arched and more conspicuous and median apodeme thickened toward base.

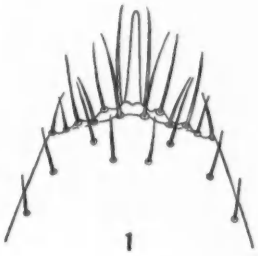
Abdomen very long, segments VI, VII, and VIII slightly more pigmented than the others. Transverse dorsal and ventral apodemes well marked but narrow and unbranched laterally. Sixth abdominal tergum about twice as broad as long, broadly emarginate along anterior margin on each side of median lobe; eight setae in first transverse row, all well developed; eight setae in second transverse row, all of about equal length and markedly longer than those in first row; four supplemental marginal setae, very fine, scarcely one-half as long as setae in second row. Genital armature of female with short, stout, slightly curved basal apodemes; apical setae small, inconspicuous.

Legs slender. Tarsus I with usual apical sense seta, which is clavate and equal to claw in length; dorsal sense seta rather short, clavate, situated at about one-third the distance from base to apex of tarsus. Tarsus III with short, dorsal, subapical spine extending to base of tarsal claw.

Length of head (including labrum), 0.21 mm.; width, 0.12 mm.

EXPLANATION OF PLATE I

Fig. 1. *Eosentomon rostratum*, new species. Dorsal view of anterior part of head, × 350. Fig. 2. *Eosentomon vermiforme* Ewing. Dorsal view of left maxilla, × 700. Fig. 3. *Eosentomon vermiforme* Ewing. Ventral view of male genital armature, × 350. Fig. 4. *Eosentomon vermiforme* Ewing. Dorsal view of sixth abdominal segment, × 350. Fig. 5. *Eosentomon vermiforme* Ewing. Right spiracle of mesothorax, from above, × 350. Fig. 6. *Eosentomon vermiforme* Ewing. Ventral view of female genital armature, × 350. Fig. 7. *Eosentomon vermiforme* Ewing. Posterior view of tip of tarsus II, × 1,050.



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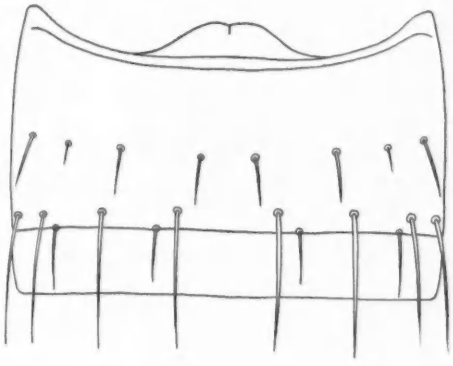

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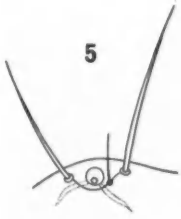

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Length of entire body, segments slightly extended, 1.37 mm.; width, 0.11 mm.

Type locality.—Highlands, North Carolina.

Type slide (*holotype, a female*).—U. S. N. M. No. 53369.

Described from two specimens, an adult female and an adult specimen with tip of abdomen broken off, taken in molding hemlock and deciduous leaves, at type locality, August 5, 1936, by J. R. Watson. These specimens were wrongly identified by the writer as *Eosentomon vermiforme* Ewing for Brimley's list of North Carolina insects (Brimley, 1938). This species, which is one of our largest proturans, is identified by the presence of the long, conspicuous, somewhat spinelike labrum. Doubtless the present writer formerly confused this labrum with the mandibles, which, when protruded and approximate, strongly suggest the labrum.

Eosentomon vermiforme Ewing

(Text fig. 2; plate I, figs. 2, 3, 4, 5, 6, and 7)

1921. *Eosentomon vermiforme* Ewing, Proc. Ent. Soc. Wash., vol. 23, no. 9, p. 194; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 712; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 130.

A large, vermiform species, light yellowish throughout. Head long, broadest at region of attachment of maxillary branches of tentorium, converging lateral margins almost straight. Labrum short, broad, with apex narrowly rounded. Pseudoculi distinctly oval, each situated at about middle of lateral margin of head. Tentorium well developed; body of tentorium about one-fourth as long as head; maxillary branch considerably stouter than cardo, extending unbranched to head wall; labial branch small, slender, almost straight, rodlike, extending about one-half distance to posterior margin of head. Sagittal keel of dorsum short, distinct.

Thorax less distinct than usual for the genus. Prothorax about as broad as long; pronotum entire, broadly rounded in front, bearing the usual four setae, the inner pair longer and stouter than the outer. Mesothorax as broad as long; mesonotum without apodemes; spiracles conspicuous, each with an anterior and a posterior tracheal recess; spiracular setae as usual, except that the posterior one is very much longer than the anterior; mesosternum with anterior, marginal apodeme and conspicuous median bar. Metathorax similar to mesothorax but slightly broader; metanotum with rather short and poorly developed transverse and median apodemes, the latter without terminal cross bar and extending only about half the distance to posterior margin of metanotum; metasternum without transverse apodeme.

Abdomen long, slightly broadest near base. Transverse dorsal and ventral apodemes unbranched and rather conspicuous. Sixth abdominal tergum fully twice as broad as long, its twenty setae in typical arrangement for the genus, next to outside seta in front row only about one-half as long as others in this row, supplementary marginal setae rather long but fine. Genital armature of male with very conspicuous, basal apodemal rods almost parallel, and sclerite at base of penis forming a

square. Genital armature of female with basal apodemes forming a horseshoe-shaped structure; apical setae apparently absent.

Legs somewhat small in comparison with the large body. Tarsus I slender and well sclerotized; apical sense seta almost reaching tip of tarsal claw; empodial process very distinct, almost as long as tarsal claw. Tarsus III with subapical dorsal spine extending to base of claw.

Length of head, including labrum, 0.17 mm.; width, 0.08 mm. Length of entire body, segments slightly extended, 1.29 mm.; width, 0.17 mm.

Type locality.—Takoma Park, Maryland.

Type slide (holotype).—U. S. N. M. No. 24578.

Specimens at hand from the following localities:

Arkansas: Cross County, 1 male, in soil of peach orchard, June 15, 1936, W. F. Turner. St. Francis County, 2 males, in soil of peach orchard, June 15, 1936, W. F. Turner.

Illinois: Union County, 1 male, in soil of peach orchard, June 3, 1934, W. F. Turner.

Maryland: Plummer Island (at or near), 1 female, March 2, 1924, R. C. Shannon and H. S. Barber; 2 males and 4 females, in dead leaves, March 18, 1924, R. C. Shannon; 1 female, in decaying leaves, April 16, 1924, H. S. Barber; 1 female, in decaying leaves, May 5, 1924, H. S. Barber; 1 male, in moist decaying leaves, November 19, 1925, H. E. Ewing. Takoma Park, 2 females, in decaying leaves, February 14, 1921, H. E. Ewing; 1 male, in decaying leaves, April 3, 1921, H. E. Ewing.

Texas: Houston, 1 injured specimen questionably identified as *E. vermiforme*, under bark of decaying loblolly pine twig, October 9, 1921, H. E. Ewing.

Virginia: Potomac River (south shore near Plummer Island, Maryland), 4 females, in leaf litter, March 26, 1924, H. S. Barber. Prospect Hill (near Great Falls), 2 males in decaying leaves and twigs, September 25, 1921, H. E. Ewing.

This species appears to be peculiar, as has been previously stated (page 510), in that six eggs approach full size at the same time in the oviducts. In stained specimens these large eggs stand out in a striking manner.

Eosentomon wheeleri Silvestri

(Plate II, figs. 8, 9, 10, and 11)

1909. *Eosentomon wheeleri* Silvestri, Atti R. Accad. Lincei, ser. 5, vol. 18, p. 8; 1909 (?) Berlese, Redia, vol. 6, p. 166; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 712; 1932, Mills, Bul. Brooklyn Ent. Soc. vol. 27, p. 130.

1909. (?) *Eosentomon wheeleri mexicanum* Silvestri, Atti R. Accad. Lincei, ser. 5, vol. 18, p. 9.

1932. *Eosentomon armatum* Mills (not Stach), Bul. Brooklyn Ent. Soc., vol. 27, p. 130.

1939. *Eosentomon millsi* Womersley, Bul. Brooklyn Ent. Soc., vol. 33, p. 221, figs. D-G.

Medium-sized species, yellowish throughout, the basal segments, thorax, and last two pairs of legs being only very slightly paler than

other parts. Head with lateral margins appearing slightly outcurved from above. Labrum short. Pseudoculi small, frequently indistinct, each situated at about middle of lateral margin of head and immediately behind a rather short, stout seta. Tentorium well sclerotized, body of tentorium about one-third as long as head, expanding posteriorly until it bifurcates; maxillary branch very stout, stouter than cardo, and of about equal width throughout; labial branch broadened at base and extending half the distance to posterior margin of head.

Thorax with segments strongly demarcated. Prothorax equal to head in width; pronotum larger than usual, about one-half as long as broad, setae subequal. Mesothorax as broad as long; transverse apodeme of mesonotum short, curved; median apodeme about two-thirds as long as mesonotum and ending in a conspicuous transverse bar bearing a seta at each end. Metathorax similar to mesothorax but slightly stouter; metanotal apodemes similar to mesonotal apodemes but better developed; metasternum divided into two parts, eumetasternum very broad with eight subequal setae, metasternellum with characteristic, thickened, sclerotic design forming a U-shaped anterior part and a posterior transverse bar.

Abdomen with sides subparallel for most of its length. Transverse dorsal and ventral apodemes distinct and typical of genus. Sixth abdominal tergum with only six setae in first row, the next to lateral seta missing; four supplementary marginal setae very fine and easily overlooked. Abdominal appendages typical of genus. Genital armature of male with stout, straight, parallel, basal apodemes and a square sclerite at base of penis. Genital armature of female rather short and stout, without apical setae.

Legs medium in length. Tarsus I somewhat stout; apical sense seta shorter than claw; dorsal sense seta very short, strongly clavate, situated at about three-sevenths the distance from base of tarsal claw to base of tarsus. Tarsus III short, but slightly longer than tibia, with ventral subapical spur curved, setalike, and extending beyond base of tarsal claw.

Length of head, including labrum, 0.13 mm.; width, 0.07 mm. Length of entire body, segments slightly extended, 0.99 mm.; width, 0.13 mm.

Type locality.—New York City.

Type specimen.—Location not known to author.

Material examined as follows:

Maryland: Takoma Park, 1 female, in decaying leaves, February 14, 1921; 1 female, in mixture of decaying leaves and twigs, March 1, 1921; 1 immature specimen, in rotting oak stump, March 13, 1921; 1 female, in decaying leaves and twigs, April 10, 1921; all collected by H. E. Ewing.

Virginia: Elk Garden Ridge, Jefferson National Forest, 3 males, 2 females, and 2 nymphs, September 18, 1938, A. B. Gurney and H. E. Ewing. Mount Rogers (elevation about 5000 ft.), 2 males, 3 females, 1 protonymph, 1 deutonymph, and 2 tritonymphs, under layers of inner bark of standing dead chestnut trunks, September 19, 1938, A. B. Gurney and H. E. Ewing. Skyland, Shenandoah National Park, 1

male, 4 females, 2 deutonymphs, and 1 tritonymph +, under inner bark of standing dead chestnut trunks, September 20, 1938, A. B. Gurney and H. E. Ewing.

Texas: Sugarland, 1 male, in soil of peach orchard, February 26, 1938, L. D. Christenson.

Material not examined:

(?) *Mexico:* Jalapa, 1 male, collected by F. Silvestri.

New York: From forest mold, collected by F. Silvestri.

This species probably occurs in all the eastern states and is the common medium-sized *Eosentomon* of the northern part of the United States. It is the only proturan species the present writer has found at elevations above 4000 feet in the Blue Ridge Mountains. It is very closely related to *Eosentomon armatum* Stach, a species the writer has not seen. However, Womersley states that his *E. millsi,* here regarded as a synonym of *E. wheeleri,* differs from *E. armatum* in the chaetotaxy of abdominal segments VII and VIII.

Eosentomon pallidum Ewing

(Plate II, fig. 12)

1921. *Eosentomon pallidum* Ewing, Proc. Ent. Soc. Wash., vol. 23, p. 194, pl. 16, fig. 3; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 712; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 130.

1921. *Eosentomon minimum* Ewing, Proc. Ent. Soc. Wash., vol. 23, p. 195, pl. 16, fig. 4; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 712; 1932, Mills, Bull. Brooklyn Ent. Soc., vol. 27, p. 130.

A small, pale species. Newly emerged specimens almost white; older specimens with body and appendages light golden yellow, but color more marked on head, tarsi, and last ten segments of abdomen. Labrum indistinct or absent. Pseudoculi indistinct, dorsolateral. Tentorium poorly sclerotized; body of same about one-third as long as head; maxillary branch broadened toward base and branched at lateral margin of head; labial branch, stout, straight, extending backward for about one-half the distance to posterior margin of head.

Thorax not strongly demarcated. Prothorax not strongly overlapped dorsally by head; pronotum very indistinct, poorly sclerotized, and with little color. Mesothorax without dorsal apodemes; each spiracle with an inconspicuous anterior and posterior tracheal recess; spiracular setae short; mesosternum poorly developed. Metathorax very similar to mesothorax.

Abdomen with transverse dorsal apodemes poorly developed. Sixth abdominal tergum with only eighteen setae, the next to outer pair of anterior row absent; supplementary marginal setae minute. Abdominal appendages rather short, with distal segment of each about one-half as long as broad. Genital armature of male with well developed basal apodemes, sclerite at base of penis broader than long; basal bulb of each fork of penis well developed. Genital armature of female with basal apodemes forming a broad arch.

Legs somewhat small and short. Tarsus I with apical sense seta slightly shorter than claw and acuminate at apex; dorsal sense seta

short, acuminate at apex, situated at about one-half the distance from base to apex of tarsus. Tarsus III with dorsal spine extending to base of claw.

Length of head, 0.12 mm.; width, 0.07 mm. Length of entire body, segments slightly extended, 1.04 mm.; width of body, 0.13 mm.

Type locality.—Takoma Park, Maryland.

Type slide (holotype).—U. S. N. M. No. 24,579.

This species, in the Eastern United States, appears to be the most common one at lower altitudes. It is the only species the writer has found infesting sphagnum. The type specimen of *E. minumum* Ewing is, according to the writer's present opinion, only a well pigmented specimen of *E. pallidum* Ewing in which the head is partially collapsed due to the action of the mounting medium.

The following material is at hand:

Arkansas: Cross County, 2 deutonymphs, in soil of peach orchard, June 15, 1936, W. F. Turner. Howard County, 2 adults, in soil of peach orchard, June 8, 1936; 3 females, 2 males, 1 tritonymph, in soil of peach orchard, June 9, 1936; 2 females, in soil of peach orchard, June 10, 1936; all collected by W. F. Turner. Pike County, 1 male, 1 female, 1 tritonymph, in soil of peach orchard, June 10, 1936, W. F. Turner. St. Francis County (? *pallidum*), 1 female, 1 tritonymph, in soil of peach orchard, June 15, 1936, W. F. Turner.

California: Yuba City, 3 males, in soil of peach orchard, November 26, 1937, L. D. Christenson, D. W. Clancy, and L. S. Jones.

Florida: La Crosse, Alachua County, 2 males, March, 1927, T. H. Hubbell. St. Augustine, 1 deutonymph, no date, T. H. Hubbell.

Georgia: Fort Valley, 1 female, in soil of peach orchard, May 14, 1936, L. D. Christenson.

Illinois: Chesterville, 1 male, in decaying leaves and twigs, October 18, 1921, H. E. Ewing. Union County, 2 females, in soil of peach orchard, September 17, 1936, W. F. Turner.

Louisiana: Tallulah, 2 specimens (1 a female), under bark of decaying twigs, October 3, 1921, H. E. Ewing.

Maryland: Beltsville (bog west of town), 1 male, October 9; 1 male, October 23; 1 protonymph, October 30; all taken in sphagnum, 1938, by R. E. Snodgrass and H. E. Ewing. Chesapeake Beach, 1 female, in decaying leaves and twigs of both pines and deciduous trees, and 3 protonymphs, under bark of decaying pine twig, June 1, 1921, H. E. Ewing. Clinton, 1 tritonymph, in debris under bark of old log, August 1, 1924, H. S. Barber. Plummer Island, 1 male, "from debris," March 30, H. S. Barber.

Takoma Park, 1 male, 2 females, 1 protonymph, in decaying leaves, February 18, 1921; 1 male, 3 females, in decaying leaves, March 27, 1921; 1 female (type), in decaying leaves, April 3, 1921; 1 male, 1 female, in decaying leaves and twigs, April 10, 1921; 1 protonymph, 1 immature (stage?), in decaying leaves, April 24, 1921; 1 protonymph, 2 deutonymphs, under bark of decaying twigs, May 10, 1921; 2 males, 1 immature (stage?), in decaying leaves and twigs, July 15, 1921; all taken by H. E. Ewing.

Pennsylvania: Huntington County, 1 male, in decaying leaves, June 24, 1923, H. E. Ewing.

Texas: Bangs, 2 females, in soil of peach orchard, August 18, 1937, and 1 female, same situation, February 9, 1938; all collected by L. D. Christenson, D. W. Clancy, and L. S. Jones. Brown County (? *pallidum*), 2 females, 1 adult (sex?), in soil of peach nursery, October 5, 1937, W. F. Turner. Houston, 1 male, under bark of decaying twig, October 9, 1921, H. E. Ewing. Tyler, 1 female, 4 males, in soil of peach orchard, September 1, 1937, L. D. Christenson, D. W. Clancy, and L. S. Jones.

Virginia: Bluemont (near, in mountains, elevation about 1200 ft.), 1 male, 1 female, 1 deutonymph, 1 tritonymph +, in decaying leaves and twigs, August 28, 1921, H. E. Ewing. Prospect Hill (not far from Potomac River), 1 female with fully formed egg, in decaying leaves and twigs, September 25, 1921, by H. E. Ewing.

Eosentomon pusillum, new species

(Plate II, fig. 13)

A very small, pale species. Head short, rounded, without visible labrum. Pseudoculi not visible. Tentorium poorly developed; body of tentorium rather short, about one-fourth as long as head; maxillary branch stouter than cardo and unbranched distally; labial branch slender, straight, extending about two-fifths distance to posterior margin of head.

Prothorax very soft; pronotum with short, minute setae. Mesothorax very slightly yellowish; mesonotum with inconspicuous spiracles and no long setae; apodemes absent. Metathorax very similar to mesothorax, with minute setae and no apodemes.

Abdomen with sides subparallel. Transverse dorsal and ventral apodemes visible, but very poorly developed. Sixth abdominal segment with six very minute setae in first dorsal row and the same number of slightly larger setae in second dorsal row; supplementary marginal setae not visible. Abdominal appendages typical of the genus. Genital armature of female with almost straight, divergent, basal apodemes and no apical setae.

Legs weak. Tarsus I slightly swollen; empodial process not visible; apical sense seta slightly shorter than claw; dorsal sense seta not observed. Tarsus III rather small, without subapical spine.

Length of head, 0.09 mm.; width, 0.05 mm. Length of entire body, segments slightly extended, 0.57 mm.; width, 0.06 mm.

Type locality.—Orlando, Florida.

Type slide (holotype).—U. S. N. M. No. 53370.

Described from 1 female taken in decaying leaves and twigs at type locality, May 26, 1922, by H. E. Ewing and 2 females and 1 young, taken in soil from peach orchard in Moore County, North Carolina, May 8, 1937, by W. F. Turner. This species differs from all other North American species of its genus in its minute size and in the smallness of the body setae, most of which can be detected only with difficulty.

Eosentomon yosemitensis Ewing

(Plate II, fig. 14)

1927. *Eosentomon yosemitensis* Ewing, Proc. Ent. Soc. Wash., vol. 29, no. 6, p. 146; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 712; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 130.

A small species; abdomen, tips of legs, and head light yellowish. Head rounded laterally, about one and one-half times as long as broad. Labrum not visible. Pseudoculi inconspicuous, each situated at about middle of lateral margin of head. Tentorium with flattened body and primary fork; maxillary branch about twice as broad as cardo; labial branch a very slender, straight rod, extending for about two-fifths the distance to posterior margin of head.

Prothorax somewhat reduced; pronotum poorly defined, with four dorsal setae in transverse row. Mesothorax with poorly sclerotized mesonotum; transverse apodeme a faint, narrow, internal ridge extending about half way across dorsum; median apodeme vestigial; spiracles conspicuous. Metathorax similar to mesothorax but with apodemes somewhat better developed.

Abdomen with first eight segments of about equal width. Transverse dorsal and ventral apodemes poorly developed, only slightly thickened toward median line and unbranched laterally. Sixth abdominal tergum with only sixteen setae, the next to inner and next to outer setae on each side in front row absent; supplementary setae in usual position, but very minute. Abdominal appendages larger than usual for a small species. Genital armature of female with almost straight basal apodemes; apical setae present.

Legs rather weak. Tarsus I with setae each arising from a small tubercle; claw curved throughout its length and very sharp; sense setae not visible in the only specimen known. Tarsus II without spine. Tarsus III with slender dorsal spine.

Length of head, 0.12 mm.; width, 0.07 mm. Length of entire body, with segments somewhat extended, 1.01 mm.; width, 0.12 mm.

Type locality.—Yosemite Valley, California.

Type slide (holotype).—U. S. N. M. No. 40485.

Described from only known specimen, a female, taken from decaying leaves and twigs collected from floor of Yosemite Valley, April 15, 1927, by H. E. Ewing. This species differs from all the other North American species of its genus in that the setae on tarsus I arise from definite tubercles.

EXPLANATION OF PLATE II

Fig. 8. *Eosentomon wheeleri* Silvestri. Distal part of tarsis III, lateral view, × 500. Fig. 9. *Eosentomon wheeleri* Silvestri. View of inner aspect of right abdom-appendage III, × 350. Fig. 10. *Eosentomon wheeleri* Silvestri. Dorsal view of metanotal apodemes of a specimen stained with acid fuchsin, × 350. Fig. 11. *Eosentomon wheeleri* Silvestri. Ventral view of metasternal region of a specimen stained with acid fuchsin, × 350.

Fig. 12. *Eosentomon pallidum* Ewing. View of inner aspect of left tarsus I (with setae omitted), × 350. Fig. 13. *Eosentomon pusillum*, new species. Dorsal view of female genital armature, × 700. Fig. 14. *Eosentomon yosemitensis* Ewing. Dorsal view of tentorium, with outline of head, × 350. Fig. 15. *Protentomon transitans* Ewing. Lateral view of abdominal appendages of right side, × 350. Fig. 16. *Microentomon perpusillum* (Berlese). Dorsal view of abdominal segment VII of tritonymph, × 350.

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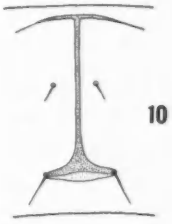

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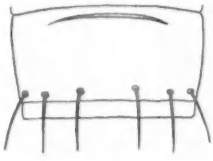

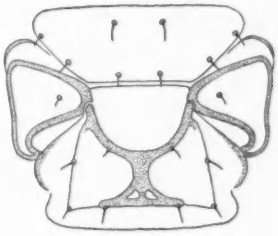

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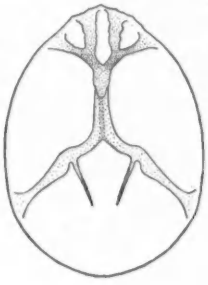

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Family **Protentomidae** Ewing

1936. *Protentomidae* Ewing, Proc. Biol. Soc. Wash., vol. 49, p. 165.

Tracheae and spiracles absent. Thorax not sharply differentiated from abdomen. Typical abdominal terga without transverse sutures and laterotergites. Vestigal abdominal appendage I, 2-segmented; II, either 2-segmented, or 1-segmented; III, 1-segmented. Segment VIII of abdomen usually with a pair of pectines. Front legs considerably longer than others; tarsus I with or without specialized sensory setae.

Contains two subfamilies: **Protentominae** Mills and **Microentominae** new subfamily.

The family Protentomidae is clearly intermediate between the more generalized family Eosentomidae and the most specialized family Acerentomidae. It has in common with the former family the simple unsutured abdominal terga, and with the latter family the absence of the tracheae and spiracles.

Subfamily **Protentominae** Mills

1927. *Meroentominae* Womersley, Ent. Mon. Mag., vol. 63, p. 141 (based on *Meroentomon* Womersley, 1927, a synonym of *Protentomon* Ewing, 1921); 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 711; 1932, Womersley, Proc. Linn. Soc. New South Wales, vol. 57, pts. 1–2, nos. 239–240, p. 71.

1932. *Protentomoninae* Mills, Bull. Brooklyn Ent. Soc., vol. 27, p. 129. (Emended to Protentominae by Womerlsey, citation in synonymy, Bul. Brooklyn Ent. Soc., vol. 33, p. 219.)

1939. *Proturentominae* Womersley, Bul. Brooklyn Ent. Soc., vol. 33, p. 219.

Vestigial abdominal appendage I, 2-segmented; II, 2-segmented and equal to I; III, 1-segmented and papillalike. Abdominal segment IX longer than X; X longer than XI; VIII with pair of pectines. Typical abdominal segments each with one complete and one incomplete transverse dorsal row of setae. Tarsus I somewhat shortened and with several modified setae including one or more clavate sense setae.

Contains two genera: **Protentomon** Ewing and **Proturentomon** Silvestri.

The subfamily name Protentomoninae Mills, as emended by Womersley (1932) to Protentominae, having priority, should stand for this subfamily instead of Proturentominae proposed by Womersley to take its place. Womersley's subfamily name is based upon the reinstated genus *Proturentomon* Silvestri (1909) which antedates *Protentomon* Ewing (1921), but the oldest subfamily name available is based upon the latter genus.

Genus **Proturentomon** Silvestri

1909 (Jan.) *Proturentomon* Silvestri, Atti R. Acad. Lincei, Ser. 5, vol. 18, p. 10; 1936, Bagnall (in part), An. Mag. Nat. Hist., ser. 10, vol. 17, p. 210; 1936, Ewing, Proc. Biol. Soc. Wash., vol. 49, p. 160; 1939, Womersley, Bul. Brooklyn Ent. Soc., vol. 33, p. 220.

1909. *Acerentulus* (in part) Berlese, Redia, vol. 6, p. 39, and various other authors up to Bagnall, 1936.

1927. *Paraentomon* Womersley, Ent. Mon. Mag., vol. 63, p. 145; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 711; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 129.

1932. *Parentomon* Womersley (misprint for *Paraentomon*), Proc. Linn. Soc. New South Wales, vol. 57, pts. 1–2, nos. 239–240, p. 71.

Labrum distinct. Dorsal abdominal apodemes present; each branched laterally. Pectines on segment VIII of abdomen reduced. One complete and one incomplete transverse row of dorsal setae on each typical segment of abdomen. Tarsus I with some modified, peg-like, or slightly clavate, dorsal setae.

Type species.—*Acerentomon minimum* Berlese.

This genus is definitely closely related to *Protentomon* Ewing. Its type species needs further study and should be redescribed.

Proturentomon iowaense Womersley

1939. *Proturentomon iowaense* Womersley, Bul. Brooklyn Ent. Soc., vol. 33, p. 221, figs. A–C.

The writer has not seen an adult of this species, hence the original description by Womersley is here quoted:

> "Length 585 μ (extended). Head, anterior tarsi and apical abdominal segments fairly well chitinized and yellowish. Head shaped as figured, 67.5 μ long by 47.5 μ wide, pseudocelli small, 4 μ long. Leg I 147 μ long, tarsus provided with sensilla as in other species of the genus, 40 μ long, claw 12.5 μ long, TR = 3.2; leg II 75 μ long; leg III 82.5 μ. Abdominal appendages on I and II 2-segmented, 17.5 μ long, on III 1-segmented, shorter. Abdominal tergites chitinized towards apex. Chaetotaxy as figured; tergites with a subposterior row of 6 setae, VIII and IV to I also with 2 fine median anterior setae; sternites as figured. Abdominal segment VIII 57.5 μ long by 25 μ wide. Pectinal organ present on tergite VIII, but teeth indistinguishable. Thin and convex, but definite, abdominal apodemes present."

Type locality.—Columbus Junction, Iowa.

Type.—Location of type material not stated by Womersley.

Womersley's description was based on material (number of specimens not stated) taken at the type locality, September 26, 1932, by H. B. Mills. Questionably identified as belonging to Womersley's species is a single tritonymph fully formed, yet inside the old deutonymph skin. It was taken in St. Francis County, Arkansas, in soil of a peach orchard June 15, 1936, by W. F. Turner. Such transforming specimens, although very commonly encountered in some arthropods, are rarely found in the Protura.

Genus **Protentomon** Ewing

1921. *Protentomon* Ewing, Proc. Ent. Soc. Wash., vol. 23, no. 9, p. 195; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 127; 1936, Ewing, Proc. Biol. Soc. Wash., vol. 49, p. 162; 1939, Womersley, Bul. Brooklyn Ent. Soc., vol. 33, p. 220.

1927. *Meroentomon* Womersley, Ent. Mon. Mag., vol. 63, p. 145; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 710; 1932, Womersley, Proc. Linn. Soc. New South Wales, vol. 47, pts. 1–2, nos. 239–240, p. 71.

1936. *Proturentomon* Bagnall (in part), An. Mag. Nat. Hist., ser. 10, vol. 17, p. 210.

Labrum either absent or vestigial. Abdominal apodemes absent. Pectines on segment VIII of abdomen much reduced. Incomplete,

transverse, dorsal row of setae on typical segments of abdomen poorly represented. Tarsus I with several peglike setae.

Type species.—*Protentomon transitans* Ewing.

This genus is closely related to *Proturentomon* Silvestri, from which it is most easily separated by the absence of abdominal apodemes. Also there are fewer dorsal setae on the abdomen than in *Proturentomon*, the first transverse row being very poorly represented. Only the type species is included in the genus.

Protentomon transitans Ewing

(Plate II, fig. 15)

1921. *Protentomon transitans* Ewing, Proc. Ent. Soc. Wash., vol. 23, p. 196, pl. 16, fig. 5; 1923, Mills, Bull. Brooklyn Ent. Soc., vol. 27, p. 129.
1927. *Meroentomon transitans* (Womersley), Ent. Mon. Mag., vol. 63, p. 145; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 711.
1936. *Proturentomon transitans* (Bagnall), An. Mag. Nat. Hist., ser. 10, vol. 17, p. 211.

Small, white species. Head rather short, broadest near base. Pseudoculi conspicuous, oval, each situated near lateral margin of head at about one-half distance from apex to base. Tentorium scarcely visible in unstained specimen.

Thorax large. Prothorax larger than usual, the exposed, dorsal part being about three-fifths as long as mesothorax. Mesothorax with large mesonotum completely covering the dorsum and extending half way down on the sides. Metathorax subequal to mesothorax. Thoracic sterna poorly developed. Thorax almost devoid of visible setae.

Abdomen long; dorsal setae minute except for those on segments VII to XII, which are fairly conspicuous. Abdominal segment IX about two-thirds as long as VIII, and VIII two-thirds as long as VII. Abdominal appendages I and II the same; each with a large, subcylindrical, basal segment bearing three lateral setae, and a small, ringlike, distal segment. Abdominal appendage III one-segmented and shaped as in *Acerentomon*. Genital armature of male conspicuous; sclerite at base of penis broad, but almost hyaline; basal bulb of each fork of penis well developed.

Legs short; first pair only slightly longer than the others. Tarsus I with some of the dorsal setae peglike to clavate; claw similar to claws of other tarsi but somewhat longer; vestigial empodium very short and small. Tarsus III short, with a small, subterminal, ventral, spurlike spine near base of claw and a similar, but longer, subterminal, dorsal spine.

Length of head, 0.11 mm. Length of entire body, segments very slightly extended, 0.73 mm.

Type locality.—Takoma Park, Maryland.

Type slide (holoytpe).—U. S. N. M. No. 24581.

Described from the holotype, the only specimen known, which was taken in decaying leaves at the type locality April 24, 1921, by H. E. Ewing. This specimen was mounted in balsam and does not show properly some of the finer structures. Because of its very fragile nature it appeared inadvisable to remount it. Womersley's (1927a) statement that the original description of this species was probably based on a submature form is without justification.

Subfamily **Microentominae**, New Subfamily

Vestigial abdominal appendage I, 2-segmented; II and III, 1-segmented, subequal, papillalike. Abdominal segments IX, X, and XI, subequal in length; VIII without pectines. Typical abdominal segments with only a single transverse row of dorsal setae, the anterior row absent. Tarsus I somewhat shortened, without sense setae. Contains the smallest of the Protura.

A single genus: **Microentomon** Ewing.

This subfamily is very distinct. The specimens are so exceedingly small, however, that there is a possibility that some of the characters have been overlooked or misinterpreted.

Genus **Microentomon** Ewing

1921. *Microentomon* Ewing, Proc. Ent. Soc. Wash., vol. 23, p. 199; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 711; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 127; 1936, Ewing, Proc. Biol. Soc. Wash., vol. 49, p. 162.

Labrum absent. Prothorax but slightly overlapped dorsally by head; pronotum large. Mesothorax and metathorax subequal; each with two complete transverse rows of dorsal setae and without apodemes. Abdomen practically without constrictions at junction of segments. Abdominal apodemes broadly arched and not thickened near the middle.

Type species.—Microentomon minutum Ewing (a synonym of *Acerentomon perpusillus* Berlese).

But a single species is represented in this genus, and it is very rare.

Microentomon perpusillum (Berlese)

(Plate II, fig. 16)

1909. *Acerentulus perpusillus* Berlese, Redia, vol. 6, p. 48; pl. 1, fig. 9; pl. 2, fig. 11; pl. VI, fig. 56.

1921. *Microentomon minutum* Ewing, Proc. Ent. Soc. Wash., vol. 23, p. 200, pl. 16, fig. 13; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 711; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 127; 1936, Ewing, Proc. Biol. Soc. Wash., vol. 49, p. 162.

Smallest known proturan; entirely white. Head short and broad, about three-fifths as broad as long. Labrum absent. Pseudoculi small, oval, dorso-lateral. Tentorium not visible in old mounts.

Thorax poorly separated from abdomen. Prothorax large; pronotum large, with a single transverse row of four minute dorsal setae. Mesothorax as broad as long, broadest near anterior border; without apodemes; with two transverse dorsal rows of setae, four setae in a row. Metathorax subequal and similar to mesothorax. Thoracic sterna very poorly developed.

Abdomen very slightly swollen. Typical segments each with a single transverse dorsal row of eight setae, counting the end setae in the row, although they are lateral in position. Dorsal apodemes small; each consisting of a simple arch extending about one-half the distance across the segment, and possibly showing an indication of branching laterally.

Legs small, with short claws. Tarsus I of almost equal width throughout; all of its seta apparently unmodified; claw similar to claws of other tarsi but slightly longer. Tarsus III about one and one-third times as long as tibia III; without subterminal spine; claw curved, very sharp, with empodial process.

Length of body, well extended (according to Berlese), 0.60 mm.

Type locality.—Pisa, Italy.

Type (*holotype*).—In the Berlese Collection.

The description of our American form of *Microentomon*, *M. minutum* Ewing, was based upon three immature specimens, taken from decaying leaves and twigs at Takoma Park, Maryland. These three specimens, however, represented only a few of several that were studied alive under magnification. The present writer is sure that among these live specimens there were some adults. The favorite habitat for this species, the smallest of all proturans, is under the bark of small, moist, decaying twigs, found in rather deep forest ground litter. It had been hoped that more specimens would be obtained so that a stained mount could be made, but soon after the described specimens were taken, building operations destroyed the small strip of woods where they occurred.

A careful examination of the immature specimens and my original description of *M. minutum* shows an almost complete agreement with Berlese's description and figures of *perpusillum* except for the nature of the dorsal abdominal apodemes. In my immature specimens these are unbranched, while Berlese represents them as being very slightly branched laterally in his mature female specimen. This difference might well be due to the difference in the ages of the specimens.

It is to be hoped that this rare and most interesting species will again be discovered and that sufficient material may be obtained to enable a thorough study to be made of it.

Family **Acerentomidae** Silvestri

1907. *Acerentomidae* Silvestri, Bol. Lab. Zool. Gen. e Agr. R. Sc. Sup. Agr. Portici, vol. 1, p. 297; 1936, Ewing, Proc. Biol. Soc. Wash., vol. 49, p. 165.

1909. *Acerentomidae* (in part) Berlese, Redia, vol. 6, p. 25; 1927, Womersley, Ent. Mon. Mag., vol. 63, p. 141; 1930, Ionesco, Acad. Roumaine Bul. Sect. Sci., 13th Ann., no. 1–2, p. 2; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 710; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 126; 1932, Womersley, Proc. Linn. Soc. New South Wales, vol. 57, pts. 1–2, nos. 239–240, p. 71.

Tracheae and spiracles absent. Thorax only moderately differentiated from abdomen. Typical abdominal terga each with one to three transverse sutures and a pair of laterotergites. Vestigial abdominal appendage I, 2-segmented, having a large, cylindrical basal segment and a very short, ringlike, terminal one; vestigial abdominal appendages II and III, 1-segmented, small, papillalike. Typical abdominal segments with two complete transverse rows of dorsal setae. Pectines present on abdominal segment VIII and usually not reduced.

Two valid genera recognized: **Acerentomon** Silvestri and **Acerentulus** Berlese.

The family Acerentomidae is regarded as the most specialized of the three families of Protura. In this family the vestigial abdominal

appendages are most reduced, the four last abdominal segments are sharply differentiated, and the pair of pectines on abdominal segment VIII are best developed.

Genus **Acerentomon** Silvestri

1907. *Acerentomon* Silvestri, Bol. Lab. Zool. Gen. e Agr. R. Sc. Sup. Agr. Portici, vol. 1, p. 297; 1909, Berlese, Redia, vol. 6, p. 34; 1921, Ewing, Proc. Ent. Soc. Wash., vol. 23, no. 9, p. 196; 1927, Womersley, Ent. Mon. Mag., vol. 63, p. 141; 1930, Ionesco, Acad. Roumaine, Bul. Sect. Sci., 13th Ann., no. 1–2, p. 2; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 710; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 128; 1932, Womersley, Proc. Linn. Soc. New South Wales, vol. 57, pts. 1–2, nos. 239–240, p. 71; 1933, Ionesco, Not. Biol., vol. 1, p. 6; 1936, Ewing, Proc. Biol. Soc. Wash., vol. 49, p. 165.

Labrum long, slender, well sclerotized, sometimes spinelike. Maxilla with lacinia divided into two long, needlelike lobes; maxillary palpus apparently 4-segmented. Dorsal abdominal apodemes well developed, thickened toward the middle, and sometimes doubly branched laterally. Dorsal setae of abdominal segment VII usually twenty, there being eight large, subequal setae in first row and eight large and four small accessory setae in second row. Integument pigmented and sclerites thick and well formed.

Type species.—*Acerentomon doderoi* Silvestri.

Remarks.—While most species of this genus are generically distinct from those of *Acerentulus* Berlese, the two genera are rather closely connected by such species as *Acerentomon microrhinus* Berlese, and *Acerentulus floridanus* (Ewing), which was described as a species of *Acerentomon*.

Berlese (1909) regarded the maxillary palpi of *Acerentomon* as being 4-segmented. He identified the terminal sclerotized process, with its several distal branches, as a segment. However, this element may be only an unusually well developed, pronged tubercle, present at the end of the maxillary palpus in most other Protura. The presence of a slender, well sclerotized labrum is the most important identifying character for the genus.

KEY TO NORTH AMERICAN SPECIES OF ACERENTOMON

1. Length, when extended to maximum, over 1.6 mm.; color bright golden brown; labrum may be very large.....2
   Length, when extended to maximum, not over 1.5 mm.; color light yellowish brown; labrum never large, never over one-fifth as long as remainder of head.....4
2. Anterior branch of typical dorsal abdominal apodemes well developed; next to outer setae in first dorsal row on abdominal segment VII situated far forward, considerably out of line with other setae in row.....**americanum**
   Anterior branch of typical dorsal abdominal apodemes vestigial or absent; lateral setae in first dorsal row on abdominal segment VII in line, or almost in line, with other setae in row.....3
3. Labrum large, over one-fifth as long as remainder of head; accessory setae in second dorsal row on abdominal segment VII about one-third as long as large, primary setae.....**andrei**
   Labrum inconspicuous, less than one-eighth as long as head; accessory setae in second dorsal row on abdominal segment VII very minute, scarcely visible.....**christensoni**

4. Pectines on abdominal segment VIII distinct; dorsal sense seta of tarsus I long, not distinctly clavate; lateral setae of first dorsal row on abdominal segment VII in line with other setae, accessory setae in second dorsal row on same segment about one-half as long as large, primary setae. . . **occidentalis**
Pectines on abdominal segment VII very minute to vestigial; dorsal sense seta of tarsus I short and strongly clavate; lateral setae of first dorsal row on abdominal segment VII displaced anteriorly, accessory setae in second dorsal row on same segment exceedingly minute, observed with difficulty, **conurus**

Acerentomon americanum Ewing

(Plate III, fig. 17)

1921. *Acerentomon americanum* Ewing, Proc. Ent. Soc. Wash., vol. 23, p. 197, pl. 16, fig. 6; 1924, Ewing, Ent. News, vol. 35, p. 46; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 710; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 128.

A large, slender species with sclerotized parts golden brown. Head long, slender, broadest near posterior end. Labrum long, slender, but not spinelike. Pseudoculi oval, not conspicuous, each situated on lateral margin of head slightly in front of middle. Tentorium with short body, much shorter than one of primary branches; maxillary branch slender, not stouter than cardo; labial branch a very slender, straight rod, extending for two-thirds the distance to posterior margin of head.

Thorax about one and one-third times as long as head. Pronotum a slender, transverse bar, bearing a row of four setae, the outer two much shorter than the inner. Mesothorax without apodemes, entirely covered above and on upper lateral aspects by mesonotum. Metathorax larger than mesothorax; metanotum with unbranched, transverse apodeme, but without median apodeme.

Abdomen large. Transverse tergal apodemes thickened toward the middle and broadly branched laterally, posterior branch showing indications of a secondary branching at its end. Seventh abdominal tergum with a single transverse suture, and twenty dorsal setae; next to lateral seta in first transverse row situated in front of and out of line with the other setae of the row, accessory setae of second transverse row very minute, barely visible. Genital armature of female short, stout.

Legs slender. Tarsus I slender; dorsal sense seta rather short, clavate, situated slightly less than one-third the distance from base to apex of segment; claw simple, without posterior marginal spur and ventral empodial process. Tarsi II and III each with a curved, sharp claw which is provided with a small spur on its posterior margin at about one-third the distance from its base to apex.

Length of head, 0.16 mm.; width, 0.08 mm. Length of entire body, segments slightly extended, 1.17 mm.; width, 0.15 mm.

Type locality.—Takoma Park, Maryland.

Type slide (holotype).—U. S. N. M. No. 24582.

Description based upon two adult females, one taken from decaying leaves at type locality, March 27, 1921, by H. E. Ewing, and one taken in decaying leaves at Decatur, Illinois, October 21, 1921, by same collector.

Acerentomon andrei, new species

(Plate III, figs. 18 and 19)

A very large, rather stout, golden-brown species. Head long, very broadly rounded behind, broadest at about one-third distance from base to labrum. Labrum the most conspicuous of that of any American proturan, narrow, over one-fourth as long as remainder of head, apex not acute, but narrowly rounded. Pseudoculi oval, dorsolateral, situated in front two-fifths of head. Dorsal setae of head long, conspicuous. Tentorium rather poorly developed; body of same slightly shorter than one of primary branches; maxillary branch broader than cardo; labial branch small, short, extending less than one-half distance to base of head and with distal part curved strongly toward sagittal plane.

Thorax about one and one-third times as long as head including the labrum. Pronotum a slender, well sclerotized, well colored, transverse, arched bar, with a transverse row of four dorsal setae, the inner two about twice as long as the outer. Mesothorax much broader than head; mesonotum with twenty dorsal setae of varying lengths, but not arranged in transverse rows. Metathorax similar to but slightly larger than mesothorax, with simple transverse apodeme but no median apodeme.

Abdomen large. Transverse dorsal apodemes of typical segments with anterior branch vestigial or absent. Seventh abdominal tergum with unbranched transverse apodeme, a single transverse suture, and twenty dorsal setae, six in first row and fourteen in second; lateral setae in first row in line with other setae of row, accessory setae in second row six, subequal, each about one-third as long as one of large setae.

Tarsus I slender; dorsal sense seta long, somewhat spinelike, situated at about one-third distance from base of segment to its apex; claw long, without posterior marginal spur. Tarsus III with rather short but very sharp claw, which is provided with minute posterior, marginal spur.

Length of head, including labrum, 0.24 mm.; width, 0.10 mm. Length of entire body, segments considerably telescoped, 1.19 mm.; width, 0.24 mm.

Type locality.—Salt Lake, Utah.

Type slide (*holotype*).—U. S. N. M. No. 53371.

Description based upon one female taken from dead leaves, from type locality, August 3, 1937, by F. Andre, for whom the species is named.

This species, one of the largest of the order, is easily distinguished because of its long labrum.

Acerentomon christensoni, new species

(Text fig. 3; Plate III, figs. 20, 21, and 22)

A large, well sclerotized species. Head subconical, lateral margins almost straight. Labrum short, broad at base, not conspicuous. Pseudoculi circular, dorsolateral, situated in front of middle of head. Tentorium with short body, and long primary branches, each being a flat strip of chitin; maxillary branch stouter than cardo; labial branch a curved strip of chitin with its inner margin much thickened.

Pronotum a broad sclerotized band with the usual transverse row of four setae, the inner of which are slightly the longer. Mesonotum with poorly developed transverse apodeme and twenty setae, fourteen of which are marginal or submarginal and, of these fourteen, four are marginal microsetae. Metanotum similar to mesonotum but larger and with better developed transverse apodeme, chaetotaxy same as for mesonotum.

Transverse dorsal apodemes of typical abdominal segments well developed, central portion of each somewhat thickened and forming angle with lateral part; anterior branch vestigial; posterior branch well developed. Seventh abdominal tergum with one transverse line or suture, and twenty-two setae, six large ones in anterior row and eight large and eight microsetae in posterior marginal row. Abdominal appendages well developed, II and III each being over twice as long as broad at base. Genital armature of female protruded in some of mounted specimens. It is stout, with straight, divergent, basal apodemes, and spinelike apical setae.

Tarsus I long, slender; claw long, distal half strongly curved; empodial appendage short, upcurved, slightly clavate, in length equal to width of base of tarsal claw; dorsal sense seta strongly clavate, in length equal to two-fifths the width of tarsus, and situated about three times its length from base of tarsus. Tarsus III without a subapical spine, with claw curved throughout its length and provided with marginal tooth.

Length of head, 0.16 mm.; width, 0.09 mm. Length of entire body, segments slightly extended, 1.52 mm.; width, 0.17 mm.

Type locality.—Brigham, Utah.

Type slide.—U. S. N. M. No. 53379.

The following specimens are at hand:

Arizona: Sedona, 3 females, in soil of peach orchard, July 13, 1937, L. D. Christenson, D. W. Clancy, and L. S. Jones.

California: Chico, 4 females, in soil of peach orchard, June 24, 1937, L. D. Christenson, D. W. Clancy, and L. S. Jones. Yuba City, 2 tritonymphs +, in soil of peach orchard, June 7, 1937, L. D. Christenson, D. W. Clancy, and L. S. Jones.

Oregon: Ashland, 1 tritonymph +, in soil of peach orchard, June 16, 1937, L. D. Christenson, D. W. Clancy, and L. S. Jones. Medford, 2 females, in soil of peach orchard, June 15, 1937, and 3 females, same

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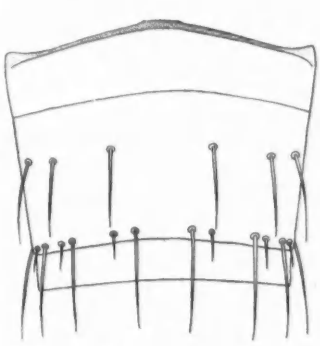
EXPLANATION OF PLATE III

Fig. 17. *Acerentomon americanum* Ewing. Dorsal view of abdominal segment VII, × 350. Fig. 18. *Acerentomon andrei*, new species. Dorsal view of anterior part of head, × 350. Fig. 19. *Acerentomon andrei*, new species. Dorsal view of abdominal segment VII, × 350. Fig. 20. *Acerentomon christensoni*, new species. Lateral view of pseudoculus of specimen cleared in potassium hydroxide and stained in acid fuchsin, × 1,050. Fig. 21. *Acerentomon christensoni*, new species. View of inner aspect of left tarsus I (with setae omitted), × 350. Fig. 22. *Acerentomon christensoni*, new species. Lateral view of abdominal segments VII–XII (setae omitted, but seta pits represented), × 350. Fig. 23. *Acerentomon occidentalis* Ewing. View of inner aspect of left tarsus I (with setae omitted), × 350. Fig. 24. *Acerentomon conurus* Ewing. Ventral view of male genital armature, × 350.



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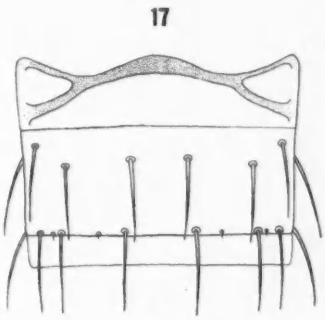

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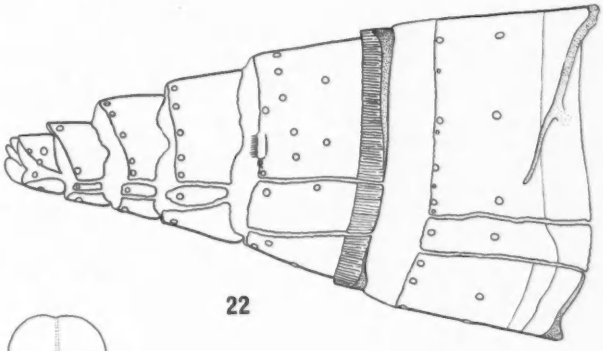

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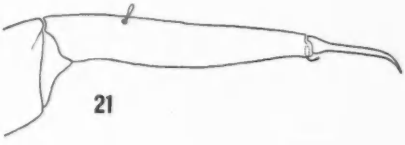

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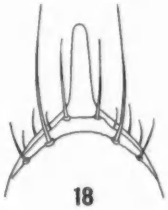

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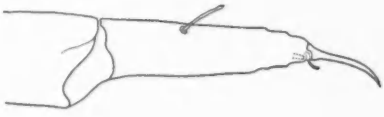

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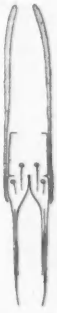

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situation, September 12, 1938; all collected by L. D. Christenson, D. W. Clancy, and L. S. Jones.

Utah: Brigham (type locality), 4 females, in soil of peach orchard, April 20, 1938, and 1 female, same situation, August 25, 1938; all collected by L. D. Christenson, D. W. Clancy, and L. S. Jones. Willard, 2 females, in soil of peach orchard, July 23, 1937, L. D. Christenson, D. W. Clancy, and L. S. Jones.

Acerentomon occidentalis, new species

(Plate III, fig. 23)

1927. *Acerentomon microrhinus* Ewing (not Berlese), Proc. Ent. Soc. Wash., vol. 29, p. 147; 1931, Tuxen (in part), Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 711; 1932, Mills (in part), Bul. Brooklyn Ent. Soc., vol. 27, p. 129.

Medium-sized, light-yellowish-brown species. Head short, broad, sides outwardly rounded. Labrum small, narrowed apically but not acuminate. Pseudoculi oval, rather small, situated dorsolaterally. Body of tentorium shorter than one of primary branches; maxillary branch stouter at base than cardo, strongly curved and tapering to apex; labial branch extending about one-half distance to posterior margin of head, curved strongly inward toward its apex.

Thorax about twice as long as head. Pronotum strongly sclerotized, outer setae of dorsal transverse row of four about one-half as long as inner. Mesonotum with small, short, simple, transverse apodeme but no median one; dorsal setae twenty-two and of varying lengths, eight forming a posterior, submarginal row. Metanotum broader than mesonotum, with similar but better developed transverse apodeme, but no median apodeme; dorsal setae twenty-two of varying lengths arranged as follows: Ten in a very irregular, transverse, anterior row, two submedian, discal, and ten forming posterior submarginal row.

Transverse dorsal apodemes of abdomen well developed, thickened toward middle, anterior lateral branch vestigial or absent. Seventh abdominal segment with simple, transverse, dorsal apodeme and two transverse dorsal sutures; only six setae in first transverse dorsal row, the lateral ones in line with the others, fourteen setae in second or marginal transverse row, six of them accessory setae of about one-half length of primary setae. Pectines on segment VIII distinct, each composed of about ten minute, closely set setae. Genital armature of female short, stout, apical setae represented by short spines.

Legs short. Tarsus I with long, not distinctly clavate, dorsal sense seta situated at about two-fifths distance from base of segment to its apex; tarsal claw without posterior marginal spur; empodial process short, upcurved. Tarsus III without spines; claw simple except for setalike, ventral, empodial process.

Length of head, including labrum, 0.16 mm.; width, 0.08 mm. Length of entire body, segments extended to maximum, 1.44 mm.; width, 0.18 mm.

Type locality.—Yosemite Valley, California.

Type slides.—U. S. N. M. No. 53372.

Description based upon three adult females taken by means of a Berlese trap by H. S. Barber from decaying leaves and twigs collected from the floor of Yosemite Valley, April 15, 1927, by H. E. Ewing. In 1927 the present writer identified these specimens as *Acerentomon microrhinus* Berlese, stating: "These specimens appear to agree in every detail with the excellent description and figures of *Acerentomon microrhinus* given by Berlese." Since then the writer has had an opportunity to compare his specimens from Yosemite Valley with specimens of *A. microrhinus* received by the United States National Museum from Berlese some years ago but not then properly labeled. In these Italian specimens the dorsal sense seta on tarsus I is much shorter than it is in *occidentalis*, and it is situated nearer the base of the segment. Also in the Italian specimens the accessory setae in the second dorsal transverse row on abdominal segment VII are much shorter than in *occidentalis* and each is situated nearer the inner of its two adjacent primary setae. It should be further stated that in Berlese's figure of *A. microrhinus* these accessory setae are not shown, although they are present on the specimens sent to the United States National Museum.

Acerentomon conurus Ewing

(Plate III, fig. 24)

1921. *Acerentomon conurus* Ewing, Proc. Ent. Soc. Wash., vol. 23, p. 197, pl. 16, figs. 7, 8; 1924, Ewing, Ent. News, vol. 35, p. 46; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 710; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 129.

A medium-sized, light-yellowish-brown species. Head rather slender, with lateral margins slightly outwardly rounded. Labrum small, short, sharply pointed. Pseudoculi oval, situated on lateral margins of head somewhat in front of middle. Body of tentorium shorter than one of primary branches; maxillary branch slender, about as stout as cardo; labial branch long and slender, extending about three-fourths the distance to posterior margin of head, and curved inward at apex.

Thorax almost twice as long as head. Prothorax about two-thirds covered above by overlapping of head. Pronotum a narrow transverse bar with customary four setae, the outer two of which are scarcely one-half as long as inner. Mesonotum with small, simple, transverse apodeme, but no median one, and with about twenty dorsal setae of varying lengths, some of them arranged in a curved, posterior, submarginal row. Metanotum similar to mesonotum, but somewhat larger and with transverse apodeme much better developed.

Transverse dorsal apodemes of typical abdominal segments broadly branched, but the anterior branch very weak. Seventh abdominal segment shaped like a broad, truncated cone, with two transverse dorsal sutures, the anterior very faint and almost invisible. Chaetotaxy of dorsum of segment VII as follows: First transverse row composed of six conspicuous, subequal setae, the two lateral being displaced anteriorly; second transverse row composed of twelve setae, four being accessory and exceedingly minute. Pectines on segment VIII much reduced. Genital armature of male with slender basal apodemes which are incurved anteriorly; sclerite at base of penis poorly developed; basal

bulb of each fork of penis moderately developed. Genital armature of female poorly sclerotized; basal apodemes short and inconspicuous.

Legs of medium length. Tarsus I with short, clavate, dorsal sense seta situated at a little less than one-third the distance from base of segment to its tip; claw slightly curved, without posterior marginal spur. Tarsi II and III each without spines, but with a claw bearing a minute, posterior, marginal spur.

Length of head, 0.12 mm.; width, 0.06 mm. Length of entire body, segments slightly extended, 0.84 mm.; width, 0.13 mm.

Type locality.—Takoma Park, Maryland.

Type slide, (holotype).—U. S. N. M. No. 24583

The following material is at hand: 5 females from decaying leaves and twigs, type locality, April 10, 1921, taken by H. E. Ewing; 1 female from decaying leaves same locality, February 18, 1921, by same collector; 1 male from dead leaves, near Plummer Island, Maryland, March 18, 1924, by Raymond Shannon; 1 female from decaying leaves, Huntington County, Pennsylvania, June 24, 1923, by H. E. Ewing.

Genus **Acerentulus** Berlese

1908. *Acerentulus* Berlese, Redia, vol. 5, p. 122; 1927, Womersley, Ent. Mon. Mag., vol. 63, p. 144; 1930, Ionesco, Acad. Roumaine, Bul. Sect. Sci., 13th Ann., no. 1–2, p. 4; 1932, Womersley, Proc. Linn. Soc. New South Wales, vol. 57, pts. 1–2, nos. 239–240, p. 71; 1934, Ionesco, Bul. Soc. Zool. France, vol. 59, p. 491, figs. 1–2.
1909. *Acerentulus* + *Acerella* Berlese, Redia, vol. 6, pp. 39, 45.
1921. *Acerentulus* + *Acerentuloides* Ewing, Proc. Ent. Soc. Wash., vol. 23, no. 9, pp. 198, 199; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 711; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 127.
1936. *Acerentulus* + *Acerentuloides* + *Acerella* Ewing, Proc. Biol. Soc. Wash., vol. 49, pp. 161, 162, 164, 165.

Labrum very minute or absent. Mandibles long, flattened, bladelike. Maxilla with lacinia divided into two long, bladelike lobes; maxillary palpus distinctly 3-segmented. Dorsal abdominal apodemes either absent, poorly developed, or well developed. Dorsal setae of abdominal segment VII eighteen, twenty, or twenty-two; six or eight in first row, twelve or fourteen in second. Integument either poorly sclerotized and pigmented or well sclerotized and pigmented.

Type species.—*Acerentomon confine* Berlese.

Remarks.—*Acerentuloides* is here combined with *Acerentulus*, the absence or presence of the transverse dorsal apodemes being considered a character variable according to the individual. In most individuals of the type species of *Acerentuloides*, *A. bicolor* Ewing, there is no indication of these apodemes. In *Acerentulus aureitarsus*, new species, the dorsal apodemes are very poorly developed and colorless, but are definitely present.

The subgenus *Acerella* Berlese (1909) is suppressed and combined with *Acerentulus* Berlese. Berlese based this subgenus on the shape of the transverse dorsal apodemes of the abdomen. This character alone could hardly be used to distinguish *Acerella*, since there is an almost

complete intergradation in the shapes of the transverse dorsal abdominal apodemes of the different species.

The fact that the dorsal abdominal apodemes do not branch in *A. tiarneus* Berlese, the type species of *Acerella*, is significant; but because of the frequent poor development of the anterior branch of the apodeme, the latter appears unbranched in some specimens, hence *Acerella* could hardly be separated from *Acerentulus* on account of the unbranched condition of the dorsal abdominal apodemes.

KEY TO NORTH AMERICAN SPECIES OF ACERENTULUS

1. Transverse dorsal apodemes either absent or without color; thorax and anterior part of abdomen colorless.....2
   Transverse dorsal apodemes present, yellowish brown or ferrugineous; thorax and abdomen with some color.....3
2. Dorsal sense seta of tarsus I pedicellate, with strongly clavate head; dorsal setae on abdominal segment VII eighteen; six in first row, twelve in second, **bicolor**
   Dorsal sense seta of tarsus I not pedicellate or clavate, but somewhat spine shaped; dorsal setae on abdominal segment VII twenty-two; eight in first row, fourteen in second.....**aureitarsus**
3. Transverse dorsal apodemes of typical abdominal segments branched laterally..4
   Transverse dorsal apodemes of typical abdominal segments may be broadened at ends but not branched.....5
4. Head with distinct transverse dorsal sutures; dorsal sense seta on tarsus I long, not clavate, longer than distance from its base to base of tarsus, **oculatus**
   Head without distinct transverse dorsal sutures; dorsal sense seta on tarsus I short, clavate.....**floridanus**
5. Tarsus I with three sense setae and apparently no empodial appendage..**tristani**
   Tarsus I with a single sense seta and an easily observed empodial appendage...6
6. Pair of setae of mesonotum nearest median line, forming with a nearby pair of setae a transverse row of four.....**barberi barberi**
   Pair of setae of mesonotum nearest median line, situated much farther posteriorly, thus not forming with pair of nearby setae a transverse row of four setae.....**barberi californicus**

Acerentulus bicolor (Ewing)

(Plate IV, fig. 25)

1921. *Acerentuloides bicolor* Ewing, Proc. Ent. Soc. Wash., vol. 23, p. 199, pl. 16, fig. 12; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d Tiere, vol. 22, Heft 4, p. 711; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 127.

A small species with head, front legs, and posterior part of abdomen light yellowish brown, remainder of body whitish. Labrum absent. Pseudoculi oval, lateral, each situated slightly in front of middle of lateral margin of head. Tentorium too poorly developed to be observed properly.

Thorax fully twice as long as head. Pronotum poorly developed, with usual transverse row of four setae, the outer two about one-half as long as inner two. Mesonotum soft, whitish. Metanotum similar to mesonotum but slightly broader.

Transverse dorsal apodemes vestigial or absent. Seventh abdominal tergum with eighteen setae; six long, subequal setae in first row and twelve setae in second row, four of which are minute accessory ones. Pectines of segment VIII much reduced. Abdominal segments IX–XII longer than in most species of genus, and in mounted specimens not

telescoped. Genital armature of female very poorly sclerotized; basal apodemes not visible.

Tarsus I with short, strongly clavate sense seta situated at about its length in front of a very long, dorsal, vertical seta; claw shorter than usual and with minute empodial appendage. Claw of tarsus III with minute spurlike process.

Length of head, 0.10 mm.; width, 0.05 mm. Length of entire body, segments slightly extended, 0.83 mm.; width, 0.09 mm.

Type locality.—Takoma Park, Maryland.

Type slide (*holotype*).—U. S. N. M. No. 24586.

Material at hand from the following localities:

Florida: Orlando, 2 females, in decaying leaves and twigs, May 26, 1922, H. E. Ewing.

Maryland: Takoma Park, 1 tritonymph +, in decaying leaves, March 27, 1921; 2 females, in decaying leaves and twigs, April 10, 1921; 1 female, in decaying leaves and twigs, 1921. All taken by H. E. Ewing.

Virginia: Great Falls of Potomac, 2 tritonymphs +, from decaying leaves and twigs, July 22, 1921, H. E. Ewing.

Acerentulus aureitarsus, new species

(Plate IV, fig. 26)

A rather large species with apex of head, front tarsi, and posterior part of abdomen bright golden brown. The thorax and anterior part of abdomen are practically colorless. Labrum very minute. Pseudoculi oval, almost lateral, situated in anterior one-half of head. Tentorium not sufficiently developed to be properly observed.

Thorax about twice as long as head. Pronotum soft, colorless; inner pair of setae very long, about three times as long as outer. Setae of mesonotum varying much in length. Metanotum similar to mesonotum but broader.

Transverse dorsal apodemes of abdomen colorless, thickened at their middles and unbranched laterally. Seventh abdominal segment with two faint transverse sutures and twenty-two dorsal setae. Eight of these, composing the irregular first row, are long, each extending considerably beyond posterior margin of tergum; fourteen setae compose the second row, four of them being conspicuous accessory setae. Genital armature of female poorly sclerotized.

Tarsus I and distal part of tarsus II and III golden brown, the remainder of the legs colorless or almost so. Sense seta of tarsus I long, somewhat spinelike, situated a little less than twice its length from base of segment. Tarsal claw II and III each with minute posterior spur.

Length of head, 0.16 mm. Length of entire body, segments extended to near maximum, 1.32 mm.; width, 0.18 mm.

Type locality.—Difficult Run (near Great Falls), Virginia.

Type slide (*holotype*).—U. S. N. M. No. 53373.

Description based on holotype, a female, taken in decaying moist leaves, at type locality, September 10, 1938, by R. E. Snodgrass and H. E. Ewing. Only one other specimen obtained, a tritonymph, in

decaying leaves and twigs, near Prospect Hill (not far from Great Falls), Virginia, September 25, 1921, by H. E. Ewing. The contrast between the parts of this proturan that are colored golden and the parts that are whitish is very striking.

Acerentulus oculatus Ewing

(Plate IV, fig. 27)

1921. *Acerentulus oculatus* Ewing, Proc. Ent. Soc. Wash., vol. 23, p. 198, pl. 16, fig. 9; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 711; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 128.

Medium-sized, light-yellowish species. Head rather short, with sides outwardly rounded; dorsally with six distinct, transverse sutures. Labrum absent. Pseudoculi oval, dorsolateral, situated between third and fourth transverse dorsal sutures. Tentorium too poorly developed to be properly observed.

Pronotum with usual transverse row of four setae, the inner pair about twice as long as outer. Mesonotum with simple transverse apodeme and twenty-four setae of varying lengths. Metanotum similar to, but slightly broader than, mesonotum.

Transverse dorsal apodemes of typical abdominal segments thickened toward the middle and narrowly branched laterally. Seventh abdominal tergum with two faint transverse sutures and twenty setae, six large ones in first transverse row and fourteen setae in second transverse row, of which six are small accessory ones. Genital armature of male with well-developed basal apodemes; forked penis with the two rami incurved and approximate at tips; genital armature of female short, poorly sclerotized.

Legs somewhat short. Tarsus I with long, slightly flattened, and slightly spatulate, dorsal sense seta, situated slightly more than its length from base of segment; claw long, curved only near apex, and with minute empodial appendage. Tarsus III without spines; claw very sharp, with posterior spur.

Length of head, 0.15 mm.; width, 0.10 mm. Length of entire body, segments slightly telescoped, 0.94 mm.; width, 0.18 mm.

Type locality.—Takoma Park, Maryland.

Type slide (holotype).—U. S. N. M. No. 24584.

Specimens at hand: Adult female (holotype) from decaying leaves, March 6, 1921, and 1 young specimen, same situation, March 27, 1921, Takoma Park, Maryland; both taken by H. E. Ewing; 1 female, Gainesville, Florida, by T. H. Hubbell; 1 male with genitalia extended, taken from breeding cell March 4, 1922, by H. E. Ewing.

In the original description of *A. oculatus* the writer stated that each pseudoculus was "provided with a hemispherical cornea-like structure." This unusual appearance was probably due to methods of preparation or mounting which caused the disc of the pseudoculus to be puffed up, thus coming to resemble a cornea. Berlese (1909) has figured pseudoculi appearing as described formerly for *oculatus* by the writer, but it is to be doubted if such strongly convex discs actually occur in living proturans.

Acerentulus floridanus (Ewing)

(Plate IV, figs. 28, 29, and 30)

1924. *Acerentomon floridanum* Ewing, Ent. News, vol. 35, p. 44.
1927. *Acerentulus floridanus* Womersley, Ent. Mon. Mag., vol. 63, p. 141; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 711; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 128.

A medium-sized, light-yellowish species. Head rather short, strongly arched above; dorsal length about twice that of ventral. Labrum minute, poorly differentiated. Pseudoculi lateral, appearing circular when viewed from side. Body of tentorium as well as primary branches much flattened; inner margins of latter thickened; maxillary branch not as stout as cardo; labial branch extending as a straight rod backward for about two-thirds the distance to posterior margin of head, then crooked inward into almost a half circle.

Pronotum well developed; inner pair of setae very long, about three times as long as the short outer pair. Mesonotum with well developed transverse apodeme; median apodeme indicated only by a minute, short line; dorsal setae twenty, four of which (an inner large and outer minute pair) form a posterior, submarginal row. Metanotum similar to mesonotum, but with transverse apodeme better developed.

Typical abdominal segments each with a conspicuous, broadly branched, transverse, dorsal apodeme and a median apodeme represented by a mere line which traverses tergal area in front of transverse suture. Seventh abdominal tergum with conspicuous, branched, transverse apodeme, a single transverse suture, and eighteen setae, six in first row and twelve in second. Genital armature of male with long, well sclerotized, basal apodemes; plate at base of penis slightly longer than broad. Genital armature of female slender; basal apodemes straight rods similar to those in male but much shorter.

Tarsus I slender; dorsal sense seta short, clavate, situated less than its length from a very long, vertical seta; claw curved and sharp, with minute, setalike, empodial appendage. Tarsus III with setae strong, almost spinelike; claw with posterior spur.

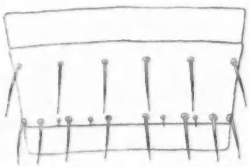
Length of head, 0.12 mm.; width, 0.08 mm. Length of entire body, segments slightly extended, 1.07 mm.; width, 0.17 mm.

Type locality.—Orlando, Florida.

Type slide (*holotype*).—U. S. N. M. No. 23766.

EXPLANATION OF PLATE IV

Fig. 25. *Acerentulus bicolor* (Ewing). Dorsal view of abdominal segment VII, × 350. Fig. 26. *Acerentulus aureitarsus*, new species. View of inner aspect of left tarsus I (with setae omitted), × 350. Fig. 27. *Acerentulus oculatus* Ewing. Dorsal view of anterior part of head, × 350. Fig. 28. *Acerentulus floridanus* (Ewing). Dorsal view of abdominal segment VII, × 350. Fig. 29. *Acerentulus floridanus* (Ewing). Ventral view of abdominal appendages of right side, × 1,050. Fig. 30. *Acerentulus floridanus* (Ewing). View of inner apsect of left tarsus I (with setae omitted), × 350. Fig. 31. *Acerentulus barberi barberi* Ewing. View of inner aspect of left tarsus I (with setae omitted), × 350. Fig. 32. *Acerentulus barberi barberi* Ewing. Dorsal view of mesonotum, × 350.



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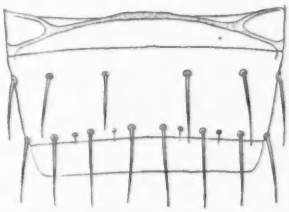

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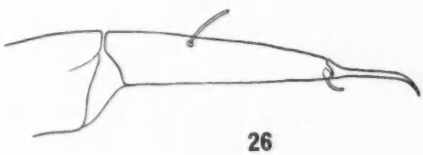

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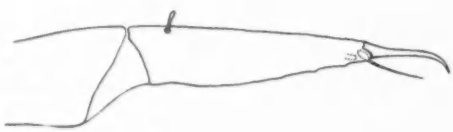

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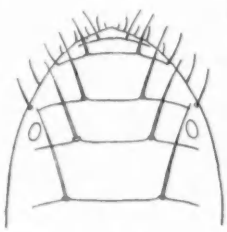

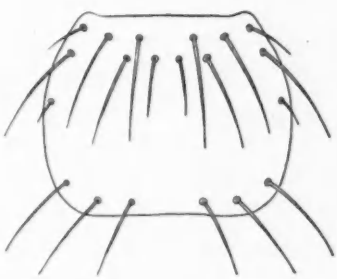

The following specimens are at hand:

California: Chico, 1 tritonymph +, in soil of peach orchard, June 24, 1937, L. D. Christenson, D. W. Clancy, and L. S. Jones.

Colorado: Palisade, 1 female, in soil of peach orchard, July 29, 1937, L. D. Christenson, D. W. Clancy, and L. S. Jones.

Florida: Orlando, 14 females, in decaying leaves and twigs, May 26, 1922, H. E. Ewing.

Georgia: Fort Valley, 3 females, in soil of peach orchard, 1936, L. D. Christenson.

North Carolina: Highlands, 3 males, 2 females, 1 deutonymph, on molding hemlock and deciduous leaves, August 5, 1936, J. R. Watson.

South Carolina: Saluda County, 1 female, in soil of peach orchard, May 13, 1936, W. F. Turner.

Utah: Brigham, 1 female, in soil of peach orchard, August 25, 1938, L. D. Christenson, D. W. Clancy, and L. S. Jones.

The specimen from Highlands, North Carolina, mentioned in this list were wrongly identified for Brimley's (1938) "Insects of North Carolina" as *Acerentulus barberi* Ewing. Among other differences *A. barberi* has the transverse, dorsal, abdominal apodemes unbranched laterally as they are in *A. floridanus*.

Acerentulus tristani Silvestri

1938. *Acerentulus tristani* Silvestri, Livro Jubilar do Professor Lauro Travassos, Rio de Janeiro, p. 443, fig. 2.

No specimens of this recently described species being at hand, the following notes are given, the same either being taken from the original Latin description or based on the original drawings.

Color: "Body more or less ferrugineous." According to the drawing of Silvestri the head is subconical, with the lateral margins very slightly outwardly rounded and the pseudoculi oval, dorsolateral, and situated slightly in front of the middle of the head. The dorsal setae on the head are, according to the original drawing, about thirty, the larger setae being arranged in two submedian rows and a posterior marginal row of four.

According to the figures given by Silvestri, the pronotum is well developed, broader than the head, and provided with the usual transverse row of four setae, the laterals being much shorter than the submedians; the metanotum is provided with a small, simple, transverse apodeme, and about sixteen setae of varying lengths, six forming a posterior marginal row.

The seventh abdominal segment is provided, according to the original figure, with a simple, slightly arched, transverse, dorsal apodeme, two transverse dorsal sutures, and twelve dorsal setae, four long ones in first row and eight long ones in second row.

Tarsus I is drawn without the usual empodial appendage, but with three sense setae as follows: A posterior clavate seta situated a little more than its length from base of segment, a middle, curved, spinelike seta situated near middle of segment, and an anterior, curved, spinelike seta situated more than its length from apex of tarsus.

"Length of body 1.10 mm., width of metanotum 0.16, length of first pair of legs 0.28."

Type locality.—"Habitat, Costa Rica: S. José, Orijuaco."

Type specimens.—Presumably in the collection of the author.

Remarks.—"This species, dedicated in memory of Frid. Tristan, is easily distinguished by the length of the claws of the first pair of legs."

Acerentulus barberi barberi Ewing

(Text fig. 1; Plate IV, figs. 31 and 32)

1921. *Acerentulus barberi* Ewing, Ent. News, vol. 32, p. 240; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 711.

1921. *Acerentulus tenuiceps* Ewing, Proc. Ent. Soc. Wash., vol. 23, p. 198, pl. 16, figs. 10, 11; 1931, Tuxen, Zeitsch. f. Morph. u. Ökol. d. Tiere, vol. 22, Heft 4, p. 711; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 128.

Medium to large species, yellowish brown in color. Head with lateral margins only slightly outwardly rounded and base subtruncate. Labrum absent. Pseudoculi almost circular, dorsolateral, situated farther forward than usual. Body of tentorium shorter than primary branches; maxillary branch slender, not so stout as cardo; labial branch slender, rather short and incurved distally, extending for about one-half distance to posterior margin of head.

Pronotum well developed; inner and outer pairs of setae situated closer than usual to each other, outer fully one-half as long as inner. Mesonotum with inconspicuous, short, transverse apodeme, and no median apodeme; twenty mesonotal setae, pair nearest median line forming with a nearby pair a transverse row of four. Metanotum similar to mesonotum but broader and with transverse apodeme better developed.

Transverse dorsal apodeme of a typical abdominal segment well developed, broadened toward middle and at ends but without true branches. Seventh abdominal segment with simple transverse dorsal apodeme, two transverse dorsal sutures, and twenty-two dorsal setae, six long ones in first row and eight long and eight small accessory setae in second row. Last four abdominal segments very short and frequently found completely telescoped into segment VIII, both in live individuals and in mounted specimens. Male genital armature with long, slightly incurved, basal apodemes; plate at base of penis slightly longer than broad. Female genital armature broad, short; basal apodemes almost straight.

Tarsus I with slightly curved, slightly clavate, dorsal sense seta, situated about one and a half times its length from base of segment; claw somewhat flattened, curved chiefly toward apex; empodial appendage setiform, two-thirds as long as claw. Tarsus III without spines; claw very sharp and with minute lateral spur.

Length of head, 0.13 mm.; width, 0.08 mm. Length of entire body, segments slightly extended, 1.11 mm.; width, 0.18 mm.

Type locality.—Takoma Park, Maryland.

Type slide (holotype).—U. S. N. M. No. 24162.

The following material examined:

Illinois: Chesterville, 10 males, 6 females, in decaying leaves and twigs, October 18, 1921, H. E. Ewing.

Maryland: Plummer Island, 2 males, from leaf litter, March 26, 1924; 2 males, 3 females, from debris, March 30, 1924; 1 (?) adult, in decaying leaves, April 16, 1924; all taken by H. S. Barber.

Takoma Park, 2 females, from decaying leaves, February 14, 1921; 1 male, 4 females, 2 (?) adults, from decaying leaves, February 16, 1921; 4 females, in decaying leaves, February 18, 1921; 3 females, 2 (?) adults, from decaying leaves, March 6, 1921; 1 male, 9 females, 2 (?) adults, same situation, March 27, 1921; 1 male, 14 females, 2 (?) adults, same situation, April 3, 1921; 1 female, in decaying leaves and twigs, April 10, 1921; all taken by H. E. Ewing.

This species varies considerably in size and also in the shape of the head. It differs from all others known to the writer in the degree to which the last four segments of the abdomen are telescoped into the eighth. Frequently they are entirely contained in this last large segment.

Acerentulus barberi californicus Hilton

1929. *Acerentulus californicus* Hilton, Jour. Ent. and Zool., vol. 21, p. 132, 1 fig.; 1932, Mills, Bul. Brooklyn Ent. Soc., vol. 27, p. 128.
1930. *Acerentulus* sp., Hilton, Ent. News, vol. 41, p. 51.

Very similar to *barberi barberi* Ewing but differing in the following: Pair of setae of mesonotum nearest median line situated much farther posteriorly than in var. *barberi*, thus not forming with pair of nearby setae a transverse row of four setae. Also seta next to outer small accessory seta on abdominal tergum VII absent in specimen sent by Hilton; while usually it is present in *barberi*.

Type locality.—Cobell's Canyon, Claremont, California.

Type (*holotype*).—A female. Pomona College Collection.

Description based upon a single female specimen sent to the United States National Museum by Hilton. It was a part of some material that had come from the type locality.

Hilton, in his comments accompanying his description of *californicus*, points out several differences between his form and *barberi*. These differences, however, are due entirely, or almost entirely, to individual variations and methods of clearing or mounting. The differences in coloration mentioned by Hilton really represent to a large extent differences in age of adult specimens. Recently transformed specimens of *barberi* are yellowish only at the ends of the body, but specimens several weeks old have the body practically uniformly yellowish. The pseudoculi appear very obscure from above in poorly cleared specimens, but are conspicuous from the side in well stained ones.

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REVISION OF THE CHALCID-FLIES OF THE TRIBE CHALCIDINI IN AMERICA NORTH OF MEXICO, by B. D. Burks. Proc. U. S. Nat. Mus. 88: 237–354, 9 text figures. Paper bound. Obtainable at cost from the U. S. Supt. of Documents, Washington, D. C.

We feel that sound revisional papers of some length are deserving of notice in the Annals. Dr. B. D. Burks is a graduate of the University of Illinois, and is now on the staff of the Illinois Natural History Survey. The present volume is virtually a revision and a report on the material in the collections of the Illinois Natural History Survey and of the U. S. National Museum. The revisional work has been done at the request of officials of the U. S. Bureau of Entomology and Plant Quarantine.

American hymenopterology is in sore need of reviews and revisional treatments. The one-hundred-fifteen figures (grouped as figs. 6–14) make the work usable to those who are not wholly fluent in the hymenopterists' interpretation and use of anatomical terms.—C. H. K.

A NEW SPECIES OF CHLOROCYPHA

(Order Odonata)

F. C. Fraser,
Lieutenant Colonel, Retired,
Indian Medical Service,
"Somewhere in England"

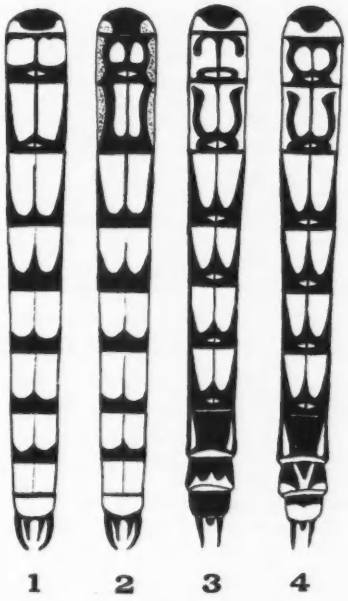
A few years ago I came into the possession of about seventy odd specimens of *Chlorocypha caligata* (Selys) (=*Libellago caligata* Selys), which were mainly collected by Dr. G. Hale Carpenter in Uganda, E. Africa. Recently whilst relaxing and setting up this series, I came to notice a marked difference in the breadth of the dilated tibiae of the males; in some this was of a moderate nature, but in others it was extremely marked. Closer examination of these two forms has revealed details of such wide differences that there can be no doubt that we are dealing with two distinct species, one of which is probably the Selysian species and the other new to science. Fortunately there is no difficulty in determining which of the two is the former species, for it is stated in the description of *L. caligata* that the sides of the first two abdominal segments are reddish. In one of the two forms before me, the sides of these segments are more or less bright ferruginous, whilst in the other form, the blue dorsal spot on segment 2 extends right out to the sides and the abdominal pattern is entirely different. The description of this insect is as follows:

Chlorocypha armageddoni sp. nov.

Male.—Abdomen, 22 mm. Hing wing, 21 mm.

Head: Labium dark brown, apices of lobes tipped with black; labrum and rest of head velvety black save for a transversely elongate quadrangular occipital spot and a small rounded spot on each side of it greenish-yellow. Prothorax black, marked with greenish-yellow as follows: a large irregular spot on each side of middle lobe, a small geminate spot on mid-dorsum of same lobe, and almost the whole of the posterior lobe. Thorax black, marked with greenish-yellow as follows: the middorsal carina finely but broadening somewhat anteriorly, a humeral and an antehumeral broadly confluent anteriorly to form a fish-hook-shaped marking, the antehumeral portion being the barb of this and curved and pointed accordingly, a narrow posthumeral stripe incomplete above, the whole of the sides save the upper portion of anterolateral suture and the whole of posterolateral suture, which

are narrowly black. Beneath greenish-yellow. Legs black, but all tibiae, which are very broadly dilated (about one-third more than in *L. caligata*), scarlet-red on extensor surface, chalky-white on the flexor surface. Abdomen black, marked with azure blue; segment 1 with its apical portion blue and enclosing a basal lunar spot of black, segment 2 black with two large blue dorsal spots narrowly separated by the black middorsal carina and extending right out to sides of segment or narrowly bordered with black at junction of tergite with pleura, about the apical third of segment black with two very small triangular blue spots at



1. Abdominal markings of *Chlorocypha armageddoni* sp. nov., male. 2. The same of *Chlorocypha caligata* (Selys), male. 3. The same of *C. armageddoni*, emale. 4. The same of *C. caligata*, female.

middorsum, segment 3 blue with the middorsal carina and sides narrowly black, the apical fourth or fifth black and with a pair of small blue spots as on segment 2, segments 4 to 8 with broad black apical rings prolonged basalwards along middorsal carina and sides to an ever decreasing degree as traced from segment to segment, segments 9 and 10 all blue. Anal appendages black, similar in shape to those of *C. caligata*.

Female.—Abdomen, 18 mm. Hind wing, 22 mm.

Head: Labium yellow with the apices of lobes black, labrum yellow, framed narrowly in black which projects midbasally so as to nearly

divide the yellow ground-colour; epistome yellow, its superior and anterior facets narrowly divided by black and with a black trapezoidal spot in front from which two fine lines run upwards and outwards to join the medial black line; genae, frons, basal joints of antennae and vertex yellow, which colour narrowly frames the ocellar space and is divided up by a network of fine black lines in the sutural depressions; the occiput black with a triangular postocular spot on each side. Colour and markings of thorax and prothorax similar to the male but the yellow rather more extensive. Legs black on flexor surface, yellow on extensor. Wings hyaline, similar in the sexes, tinted with yellow at bases in both, but this extending along costa nearly to pterostigma in the female; pterostigma black but broadly centered with yellow in the female, covering 3 to 4 cells in the male, 4 to 5 in the female, 13 to 15 postnodals, 9 to 11 antenodals, quadrilaterals traversed once in all wings of both sexes, petiolation to level of basal antenodal, reticulation close as in *caligata*. Abdomen yellow, marked with black as follows: Segment 1 with a basal lunar spot as in the male (this spot trilobate in *caligata*), segment 2 with an inverted anchor-shaped spot (in *calgiata* the black totally encloses two subtriangular spots of yellow and two small triangular spots near apical border), segment 3 with a trident-shaped marking, the forks directed basally, whilst the apical black encloses two small oval spots, segments 4 to 7 with the middorsal carina finely and the sides increasingly broadly black, so that the yellow ground colour becomes more and more limited from segment to segment, segment 8 with a narrow yellow stripe on each side, otherwise entirely black (segments 3 to 8 are thus seen to be similar to those of *calgiata*), segment 9 with the basal two-thirds black, the apical border of the black produced into two obtuse points, segment 10 entirely black. Anal appendages shortly conical, black.

Habitat: Along the tributaries of the Nile in Buganda, East Africa. Numerous specimens of both sexes collected by Dr. G. Hale Carpenter, 1927.

This new species differs from *caligata* by its more dilated tibiae and greater extent of blue markings of abdomen in the male, and by the different markings on segments 1, 2, 9 and 10 of the abdomen in the female, these markings being less extensive on the first two of these segments and more extensive on the latter two. Type in my own collection.

AGELENID SPIDERS OF THE GENUS CICURINA, by RALPH V. CHAMBERLIN AND WILTON IVIE. 108 pages, 97 figs. on 12 pls., 6.5 x 10 inches. Published as No. 13, Vol. 30, 1940, of the Bulletin of the University of Utah, Salt Lake City, Utah.

It strains editorial rules to call attention to articles in a journal. We are lengthening our rule to cover this monograph on a genus of spiders. It is just one example of the publications on spiders by these authors which have appeared in the Bulletin of the University of Utah. The twelve lovely plates of male and female organs of the various species drawn by Wilton Ivie make this an outstanding monograph of Cicurina.—C. H. K.

FOUR NEW SPECIES OF WESTERN COLEOPTERA (CLERIDAE, BUPRESTIDAE AND CERAMBYCIDAE)

JOSEF N. KNULL,
The Ohio State University,
Columbus, Ohio

Cymatodera xavierae n. sp.

Male.—Resembling *C. tricolor* Skinner in form and color. Light brown, apical third of elytra and umbone piceous, a transverse light band on elytra between the two colors, back of middle.

Head convex; surface rugulose, punctures not evident, pubescence moderately long; antennae reaching to elytra when laid along side, scape stouter than rest of joints, second joint slightly shorter than third, joints three to ten inclusive of about equal length, eleventh joint longer.

Pronotum nearly twice as long as wide, wider at apex than at base; sides subparallel in front, expanded at middle, strongly constricted back of middle, expanded at base; disk convex; surface shining, minutely punctured, each puncture bearing a long hair. Scutellum oval, minutely punctured, pubescent.

Elytra at base wider than widest part of pronotum, widest in apical third; sides subparallel, broadly rounded at apices; disk convex; surface with punctures and striae coarse on basal two-thirds, becoming obsolete at apex, striae single, equidistant, punctures of interspaces minute, pubescence shorter than that of pronotum, of two lengths.

Body winged. Abdomen finely densely punctured, pubescence short, fifth ventral broadly emarginate, sixth ventral deeply emarginate.

Length, 6.7 mm.; width, 2 mm.

Female.—Fifth ventral only slightly emarginate, sixth ventral broadly rounded.

Holotype male, labeled Tucson, Ariz., July 12, 1937, D. J. & J. N. Knull, collectors; allotype from the same locality, Aug. 1, 1932, F. H. Parker; one paratype female from the same locality, Aug. 23, 1938, D. J. and J. N. Knull. Types in collection of the author.

This species would come in the Knausi-morosa group[1] near *C. tricolor* Skinn. It lacks the black abdominal and leg markings of Skinner's species, as well as the distinct punctures of the head and pronotum. The black elytral area does not extend in front of the white band in the new form.

[1]A. B. Wolcott, Proc. U. S. National Museum, V. 49, pp. 269–290, 1921.

Agrilus catalinae n. sp.

Male.—Bronze above and below, a pubescent stripe extending along suture of each elytron and on each side of pronotum.

Head convex, a slight median depression on vertex; surface rugulose, front densely pubescent; antennae not reaching middle of pronotum when laid along side, serrate from the fifth joint.

Pronotum wider than long, wider at apex than at base; sides parallel in front, sinuate at base; when viewed from the side, marginal and submarginal carinae joined in rear; anterior margin strongly sinuate, median lobe rather sharply rounded; base broadly emarginate at middle of each elytron; disk convex, lateral depressions well marked, prehumeral carinae rounded; surface obliquely rugose, punctures minute. Scutellum finely granulate, transversely carinate.

Elytra at base same width as base of pronotum; sides rounded back of base, constricted in middle, broadly rounded posteriorly; apices rounded, only slightly serrulate; disk convex, sutural margins elevated posteriorly, basal depressions well marked; surface imbricate-punctate, entire surface with short pubescence which forms a stripe along suture of each elytron.

Abdomen beneath sparsely pubescent, pubescence forming patches along sides of third, fourth and fifth segments, suture between first two segments indicated at sides, median depression on first and part of second segment; pygidium without projecting carina. Prosternum densely pubescent, pubescence extending along median to second segment of abdomen; prosternal lobe declivous, broadly rounded. Tibiae slender, anterior and middle pairs mucronate on inner margin at apex. Tarsal claws similar on all feet, cleft, the inner ones not turned inward and shorter than the outer ones. Genitalia similar to those of *A. malvastri* Fisher.

Length, 4.8 mm.; width, 1.1 mm.

Holotype and paratype, male specimens, collected near Tucson, Arizona, June 25, 1939, by D. J. and J. N. Knull, are in the collection of the writer.

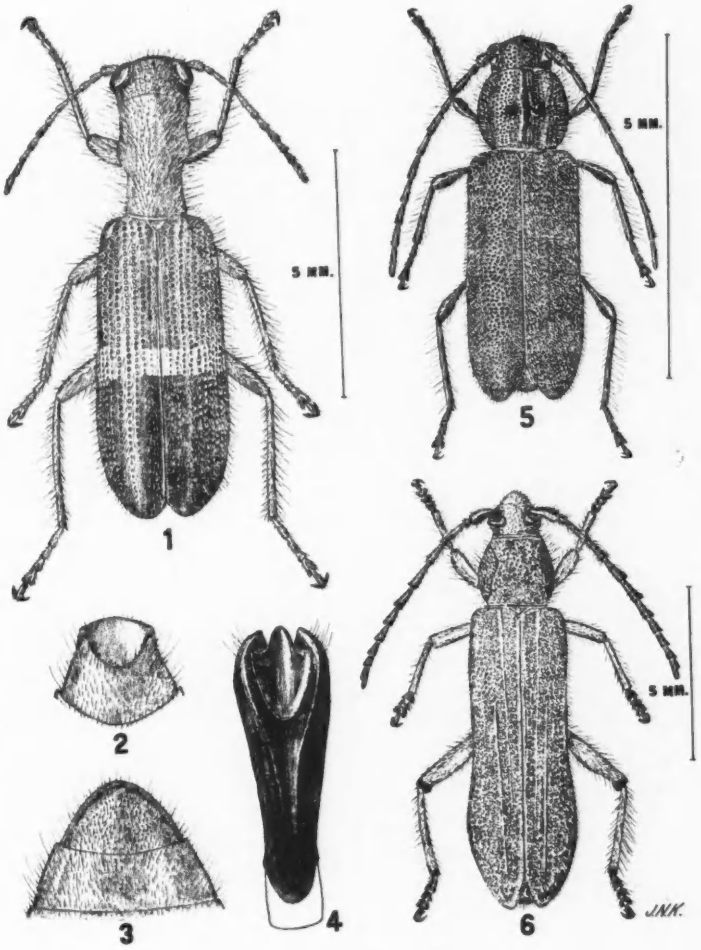
According to Fisher's key[2] this species would run to *A. aeneocephalus* Fisher. It can be separated from this species by its narrow convex pronotum and the shape of the male genitalia.

Phymatodis ursae n. sp.

Piceous throughout, shining on both surfaces.

Head coarsely punctured, punctures well spaced on front, separated by less than their own diameters on vertex; antennae reaching to apical third of elytra when laid along side, scape stout, second joint about twice as long as wide, third, fourth, fifth and sixth joints of equal length, remaining joints decreasing in length to last one which is as

[2]W. S. Fisher, U. S. National Museum Bul. 145, pp. 1–347, 1928.



1. *Cymatodera xavierae* n. sp.
2. Last ventral of male *C. xavierae* n. sp.
3. Last two ventrals of female *C. xavierae* n. sp.
4. Male genitalia of *Agrilus catalinae* n. sp.
5. *Phymatodes ursae* n. sp.
6. *Elytroleptus davisi* n. sp.

long as third, first six joints with longer pubescence than rest; head with long pubescence.

Pronotum slightly wider than long, apex and base of about equal width; sides evenly rounded from base to apex; disk convex with transverse basal depression; surface with an irregular median callosity and one on each side at middle, punctures coarse, separated by less than their own diameters, pubescence long. Scutellum triangular, depressed in middle, surface minutely punctured.

Elytra at base wider than pronotum; sides parallel, apices obtusely rounded; disk convex; surface coarsely punctured, punctures larger and closer than those of pronotum, becoming obscure toward apices, recumbent pubescence short.

Prosternum finely densely punctured. Abdomen smooth, punctures minute, pubescence long. Femora clavate.

Length, 5.2 mm.; width, 1.4 mm.

Holotype collected July 12, 1939, in Yellowstone National Park by D. J. and J. N. Knull. Specimen in writer's collection.

Dr. E. G. Linsley kindly compared the specimen with the types of *P. rainieri* Van D. and *P. nigerrimus* Van D. The former species is subglabrous, with much finer punctures, the prosternum is polished, almost impunctate and transversely rugulose. The latter species has no apical constriction of pronotum, the punctures are finer and more regular, the antennae are more slender. *P. fulgidus* Hopp. has finer, more widely separated pronotal punctures.

Elytroleptus davisi n. sp.

Ferruginous with the exception of most of ventral surface, sides of head, maxillary and labial palpi, pronotum, antennae, tips of middle and hind femora and tibiae, also tarsi black.

Head convex, rugose, a black stripe along each side and on underside, golden pubescence short, eyes deeply emarginate; antennae reaching to middle of elytra when laid along sides, scape stout, second joint as broad as long, third joint not as long as first, fourth shorter than third, fifth longer than fourth, joints six to ten inclusive gradually diminishing in length, eleventh joint pseudo-articulate, as long as fourth, joints five to eleven inclusive serrate.

Pronotum wider than long, wider at base than in front; sides broadly rounded; disk flattened, a lateral depression extending along each side; surface coarsely rugose in middle, depressions at side black, densely coarsely punctured, long golden pubescence dense. Scutellum triangular, pubescent.

Elytra at base much wider than pronotum, somewhat widened apically, sides subparallel, apices acutely rounded; disk convex, four costae on each elytron; surface coarsely closely punctured, punctures confluent along sides and toward apices, recumbent golden pubescence short.

Prosternum strigose. Abdomen smooth, shining, punctures minute, pubescence long, sparse.

Length, 11.5 mm.; width, 3.8 mm.

Holotype collected in the Davis Mountains near Fort Davis, June 10, 1939, by D. J. and J. N. Knull and in the collection of the writer.

This species somewhat resembles *E. ignitus* Lec., however, it is narrower, lacks the angled pronotum, and has the dark markings.

TROUT STREAMS, Conditions that Determine Their Productivity and Suggestions for Stream and Lake Management, by Paul R. Needham. Pages x and 233, 74 figs. 9.25 x 6.5 inches, Linen, 1938. Published by Comstock Publishing Company, Inc., 124 Roberts Place, Cornell Heights, Ithaca, New York. Price, linen, $3.00.

The present volume is written by one who grew up in a family interested in wild life and in association with a university departmental staff whose study and teaching were largely given to the scientific aspects of nature study. Paul Needham, of the U. S. Bureau of Fisheries, is a true son of James G. Needham, Entomologist and Limnologist at Cornell University. Both have had a keen interest in commercially productive wild life and particularly an interest in the life of fresh waters.

From the preface we quote: "This book is an attempt to place in the hands of anglers, sportsmen, and conservationists reliable information relating to trout and to trout streams in which they live. * * * There are many facts of importance that are well-known to fisheries workers but are little known to sportsmen. If the support of anglers is to be obtained to put into effect more modern and better balanced conservation policies, these facts must be made available to them."

No single person, because of his education with his father, his work on conservation staffs and finally with the staff of the U. S. Bureau of Fisheries, has been in better position to learn the latest and best than has the author. He has his father's gift of a comprehending observation and his willingness to write.

We give Trout Streams a notice in the Annals because the food of trout is a basic interest in the book and the food of trout consists largely of insects. A student of trout has to know aquatic insects and in a general way the field of literature covering aquatic insects. The seven chapter heads show the contents: I. Trout and Salmon; thirteen kinds of trout and salmon discussed. II. Stream Conditions, Physical and Chemical; temperature, transparency, gases in solution and pollution. III. Trout Stream Animals; predators, parasites, insects including caddisflies, mayflies, stoneflies, true flies, cranefiies, alderflies, also crustaceans, snails and clams. IV. Food Selection by Trout; by eastern brook trout, by brown trout, by rainbow trout. V. Distribution of Trout Foods; census-taking in stream beds, distribution in pools and riffles, seasonal abundance, aquatic plants, land foods, drift-net studies. VI. Propagation, Stocking and Protection; propagation of trout, aids, planting, surveys, stocking policies, large *vs.* small trout, mortality, measuring production, spawning, new planting systems needed, protection. VII. Stream and Lake Management; California check dams, improving food supply, lake improvements, spawning bed improvement, measuring angler's catches.

Besides the above there are twenty pages of appendix, giving: Names of trout, Instructions for collecting scales, Planting tables, Organization of survey crews, Methods of locating unnamed waters, and Blank forms for surveys. A very good bibliography of seven pages is included.

The volume impresses us as being condensed and as having been written with care by one who is technically familiar with all phases of trout conservation and propagation.—C. H. K.

THE SLAVE-MAKING ANT, FORMICA SANGUINEA SUBINTEGRA EMERY, ITS RAIDS, NUPTUAL FLIGHTS AND NEST STRUCTURE

MARY TALBOT
Lindenwood College, St. Charles, Missouri,
AND
CLARENCE HAMILTON KENNEDY
Ohio State University, Columbus, Ohio

The sanguinary ants, or "blood-red slave makers," have long been of interest because of their conspicuous habit of making periodic forays to capture the young of other ants and transport them to their own nests. Here the young develop, thus forming mixed colonies of red and black workers which together carry on the activities of excavation and caring for the young.

Gibraltar Island, the site of the Franz Theodore Stone Laboratory of Ohio State University, makes an ideal unit for a habit study of the slave-making ant *Formica sanguinea subintegra* Emery, and of its slave ant *Formica fusca subsericea* Say. The island lies at the west end of Lake Erie and is cut off from its nearest neighboring land, South Bass Island, by a bay one-fourth of a mile wide. It consists of six acres of rock, covered with a thin layer of soil which supports a lawn and scattered trees, and has been maintained in this condition since 1865 when J. Cooke established a summer home there.

The island has undoubtedly long ago reached the maximum population of ants which it will support and probably there is a fairly constant balance between the number of *F. fusca subsericea* and *F. sanguinea subintegra* colonies since the *sanguineas* exist at the expense of the *fuscas*. If they should increase to such an extent that they wipe out the *fuscas* they themselves probably would not survive. The *fusca* colonies are often depleted by the continuous yearly raids of the slave-makers, yet there is a surprisingly large number of colonies which are never seen until the raiding *sanguineas* find them. The number of *sanguinea* nests present at any one time was never accurately determined. The problem was complicated by the tendency of the colonies to move from their own well-established nests into those of raided colonies. Several such moves might be

made during a summer so if a colony were lost track of and another discovered later, it could not be determined whether this was the original colony or a new one. However, there is good evidence from several years' observations that there are at least four large active *sanguinea* colonies on the island. There may be several more.

RAIDING ACTIVITIES

Raiding activities have been noted during the summers of 1930, '31, '33, '34, '35, '36 and '37, and in 1939 the information so gathered was rounded out by detailed study from the beginning of the raiding season until the end of August. Three large colonies were located for the observations. These, because of their locations, were named the Walk Nest, the Dock Nest and the North Nest. Daily observations were made on all three. However, the data gathered are almost entirely from the Walk and the Dock Nests since the North colony moved to an unknown location near the beginning of the raiding season and at the end of August had not returned. The nest was not entirely abandoned, for some blacks and a very few reds remained behind, keeping some entrance open.

Records from Previous Years.—It is known that the Dock Nest was in the present position in 1935, 1936 and 1937, and in these years it made raids to the dining hall, to Stone Memorial, and along the dock. The Walk Nest was found in its present location in 1930. On July 28, 1930, it moved to a new nest east of the caretaker's house, the workers carrying larvae, pupae, *fusca* workers, and *sanguinea* winged females. Raids were carried on from this new base. A nest found in 1931 near the lake by the caretaker's house may have been this same colony, and so may the one found in 1933 to the right of the fork of the Castle walk. The Walk Nest was discovered again in 1934 in its original position; a flight was witnessed from that site July 27, 1936, and it remained in place during 1937. No observations were made in 1938, but in 1939 it stayed in the original location all summer.

The North Nest seems to wander more. In 1930, a nest was found just north of the Trustees' Cottage. In 1931 there was one in the depression between the dining hall and the Trustees' Cottage. This raided a nest near the cottage (the site of the 1939 nest) and moved in there. Later that summer it moved to the north of the Trustees' Cottage. Still later in the season a nest, which was probably the same colony, was found between the Trustees' Cottage and Barney Cottage.

Other nests have been located: beside the laboratory steps ('30, '31), near the Castle ('34, '35, '36, '39), beside the Power House ('31), and at the east end of the island ('34, '39).

Nest Construction and Location.—There is no sign of any mound-building tendency on the part of any ant on Gibraltar Island. This may be partly influenced by the fact that the soil is shallow over the rocks in most places or that the grass has been kept mowed for many years.

McCook's observations that the *F. fusca subsericea* colonies which are constantly raided by *sanguineas* tend to conceal their openings, can be clearly verified by watching the Gibraltar colonies. Their nests are usually located in cut grass and from the surface show only a series of scattered openings with none of the excavated earth or cast off pupae cases which so often give the clue to nest location even when no mound is formed. The number of openings varies from two or three to as high as twenty scattered over an area five feet in diameter. Seemingly most of the colonies are small in comparison with the usual species size. There is a distinct and consistent tendency to plug some or all of the entrances with soil, pebbles, or grass. This is especially conspicuous just after nests have been raided.

The mixed *sanguinea-fusca* colonies show a markedly similar tendency toward inconspicuousness which indicates strongly that the slave members of the colony determine its mechanical structure.

The Walk Nest is located on a gently sloping lawn and extends on both sides of a cement walk. It is approximately one hundred inches long and seventy-five inches wide. Entrances are scattered irregularly, usually nine or ten above the walk and five or six below it. Their positions vary as new entrances are frequently opened and old ones plugged. There is no sign of debris at any time because of the workers' care in removing and depositing it beyond the confines of the nest. Individuals have been observed to go two feet from the nest to lay down an empty pupa case or bit of soil.

The Dock Nest extends along a ridge for one hundred thirty-five inches, the entrances all lying close along the curvature of the ridge top. Usually there are eight or nine openings, the number varying from time to time even more than at the Walk Nest. The greatest number are open during the days of flight. At no time are all the entrances used, for activity shifts from day to day from one group to another, depending on which is nearest the line of raid. After a rain, those caved in are promptly reopened.

Typical Raiding Activities.—On the morning of August 7, 1939, there was no sign of any activity about the Dock Nest. Single black ants were going back and forth foraging while a few reds were standing about. At about 3:30, a group of 14 started out rather slowly from the nest; these were followed soon by other clusters. Almost immediately some returned to the home nest so that soon the column consisted of ants going in both directions. It did not progress very rapidly for the first 15 minutes. Then there was a speeding up in progress because more ants went straight forward and fewer turned back so that an advance of 48 feet was made in the next half-hour. The line was a typical exploratory one, the ants forming a broad column about three feet wide and exploring every crack along this line. There was no constant front but the line simply faded into a few scattered individuals

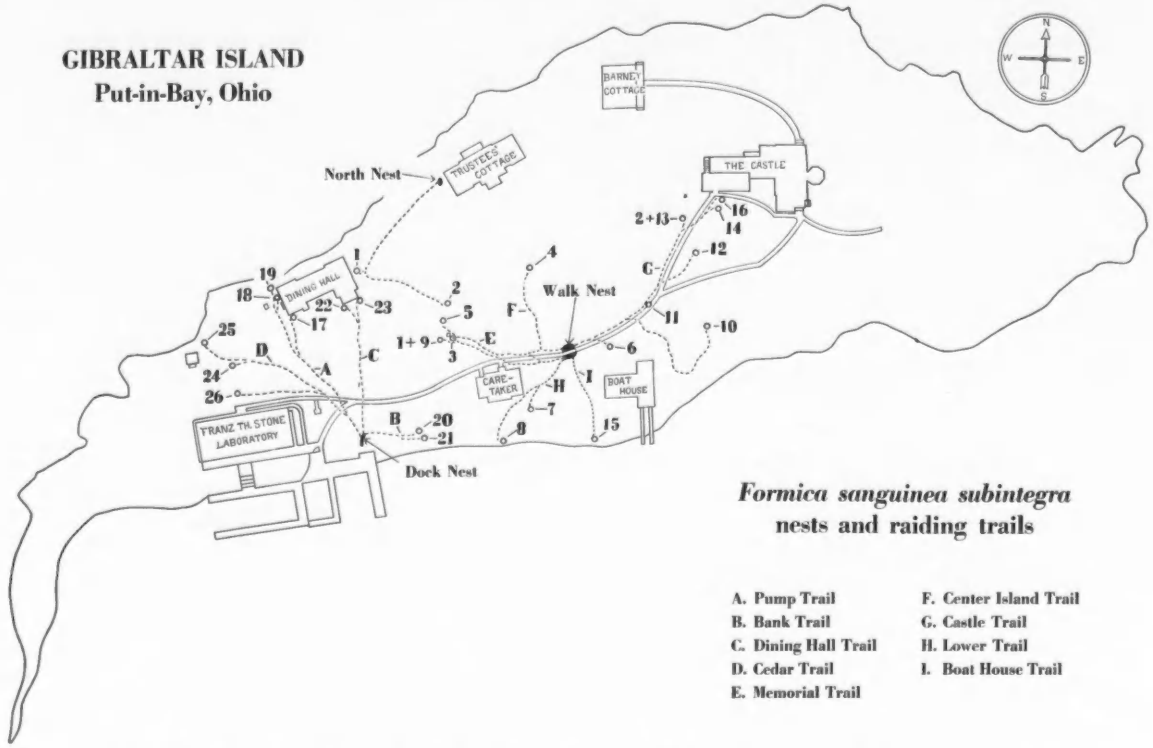


Fig. 1. Gibraltar Island, Put-in-Bay, Ohio, showing nests and raiding trails of *Formica sanguinea subintegra* and the nests (numbered) of its prey, *Formica fusca subsericea*.

making a fan-shaped end. There was no excitement and the ants moved slowly. By 5 o'clock the line had ceased to advance and more ants were returning to the nest than were going out. At 6 30 there was no trailing activity at all. That night there was a rain but the sun came out the next morning. At about 10:30, the exploratory groups started out again much as they had the afternoon before and followed the same course which the rain had not obliterated. They seemed to make no progress beyond the advance of the day before, and the line began to retreat about 11:30. By 1:30, the regular noon lull was observed and there was absolutely no activity at the nest. No further observation was made until 3:50, but at first glance it could be seen that something had happened. There were many more ants on the trail which was now but two feet wide, and they were traveling fast. The trail ended just before the dining hall in a great mass of ants gathered in a grassless area three feet in diameter which was scattered over with bits of burnt wood one-half to one inch long. Obviously a nest had been located, but it was a "plugged nest," that is a *fusca* nest whose openings had all been plugged shut by its own members. The *sanguineas* were exhibiting tremendous activity, exploring the area in minute detail and moving every bit of burnt wood encountered. At two places there was what seemed to be frenzied activity, with masses of reds tearing out bits of wood and exploring every crevice thus exposed. Evidently they were attacking two plugged entrances. Within ten minutes, one opening was penetrated and reds began disappearing in groups of 6 or 8. Immediately the first 4 black ants were routed out. Two of these walked quietly away, but the other two were pulled about a bit before being released. Within three minutes, there were streams of blacks pouring from both openings. Some were mauled but many were allowed to run away unmolested. Blacks continued to pour out for the next four minutes before a *sanguinea* appeared with the first pupa. From then on blacks, and reds with pupae, continued to leave the nest while other *sanguineas* found and unplugged more openings. A black queen which had emerged was halted once but dodged away into the grass. No individuals were killed, and those molested were invariably released uninjured. By 5:30, activity had slowed down considerably; a few blacks were still emerging and a few pupae were still being taken out by *sanguineas*. An interesting organization of *fusca* ants was occurring around the outskirts. Four black queens had by this time run out into the grass. A black worker was seen to drag one off and several other workers were carrying black workers who curled up beneath them. A group of 20–25 blacks was found gathered about a queen under a dead maple leaf and two other groups with queens were found under other bits of debris. Evidently black workers were actively gathering together into small groups all around the nest. By this time, many plugged entrances of the nest had been opened by the marauding reds and it could be seen that the raided nest was an enormous one, covering a diameter of five feet. There had been no evidence of this whatever at the beginning of the raid. Every entrance had been thoroughly plugged with the charred wood and no debris of any kind could be seen to indicate a nest. By 6:30 the line had almost

ceased, though red ants could be seen down in the galleries of the *fusca* nest. There was a rain in the night; however, it did not close the nest openings. At 7:30 the next morning everything was quiet at the raided nest. By 9:15 several reds, which had stayed overnight were seen at the main *fusca* opening and a few had just started toward the home nest with pupae. At about the same time a group of a dozen left the home nest and started along the old trail. Morning activities had begun at both ends of the line. By 9:20 pupae were being carried in a constant stream and an equal number of ants were traveling each way along the quiet, moderately-populated trail. This file lacked the numbers, compactness, speed, and excitation which marked the one just after the nest had been discovered. It also differed from the exploratory column in that it was narrower and the ants kept a steady pace, not moving off to the sides or stopping to investigate crannies. At 12:00 the noon lull occurred and the afternoon line did not begin again until 3:45. That afternoon almost no pupae were taken although the reds were still very much in possession of the captured nest, moving in and out of its galleries. Next morning (8–10–39) there was still a weak column connecting the *sanguinea* and the captured nests, but no pupae were being brought home.

When the line was visited at 3:15, it was obvious that exploratory maneuvers were again in progress. Numerous groups of ants were leaving the home nest in flurries, following the old trail to within four feet of the raided *fusca* nest where they swerved to the east and spread out into a typical broad exploratory formation four feet wide. Between 4:30 and 5:00, this broad front advanced six feet across the grass; by 5:50 the column was retreating without having found a nest. Next morning (8–11–39) activities were just beginning at 9:20 when typical groups of three to six ants were leaving the nest at intervals. The line was thin all morning and swung to the east of the previous day's exploration, and it dwindled to nothing by 11:55. No observations were made until 5:20 when it was found that the *sanguineas* had again located a nest not far from the other. Once again activities were at their height; blacks were pouring out and *sanguineas* were carrying off pupae.

The raiding of these nests has been given in detail because it is typical of the activities which went on day after day at the Dock Nest and at Skipper's Nest. Activities on the trail varied according to whether the ants were exploring, had just discovered a nest to loot, or were carrying on routine plundering. Length of noon lulls and duration of raids into the evening depended on the activities in progress. Unsuccessful raids tended to stop earlier. Most *fusca* nests were found to be thoroughly concealed by twigs, stones, or grass, and had to be unplugged before the reds could enter. This was the period of the greatest massing of ants, the most thickly populated columns, and the greatest seeming excitement. Once the reds could descend into the nest galleries blacks came pouring out with little evidence of resistance. Some were dragged out by legs, antennae, or mandibles by red workers and then were released; many more simply walked off. Some were mauled by one, two or three reds pulling at them; but they were usually

released and allowed to escape uninjured. These blacks rounded up their fellow workers and queens and reentered their nests just as soon as the reds deserted them, whether this was the next day or several days later. A few ants would carry their fellows back in the typical manner of transportation, with the transported ant curled up beneath the carrier. The nest openings were again plugged so thoroughly that often they could not be detected even though their locations had been marked previously.

Sanguineas took complete possession of the raided nests and individuals remained overnight there until the raiding was over. It was found that some blacks also stayed in the nest in seeming peacefulness. These could not be blacks of the mixed *sanguinea-fusca* home nest, for they were never seen to take part in a raid.

Trails.—Each *sanguinea* colony had certain definite well-established trails which exploring parties followed as far as possible before deviating off in search of a new colony. These trails were not, as is the case with *Camponotus*, visible pathways, but they seemed to be a habit of procedure. Probably odor played a part in their maintenance, but there was no slavish following of a line as is found in *Crematogaster*, nor did rain in any way weaken the trail. The map shows the main trails which were traversed day after day until the investigator could pick up the line at a given point and know just how the ants had come to that place from the home nest: for, example, the Pump trail of the Dock Nest always crossed the sidewalks just before they joined. (See map.) It was only after Nest No. 9 had been discovered late in the summer that the trail was shifted so that it crossed the walk to the west of the previous crossing. In a similar fashion, the Castle trail of the Walk Nest could always be picked up just to the north of the walk leading to the Castle. The way in which deviations occurred from these trails is rather interesting. After Nest No. 22 had been raided by the Dock Nest, an exploring party started out east from it and discovered No. 23. Next day the line swerved to the east before it reached No. 22 and all loot brought in from No. 23 followed this new branch which then straightened the trail and shortened the distance traveled to the home nest. Other such instances of straightening the trail were found during the summer.

When some ants from the Walk Nest located Nest No. 10, a strong line was already exploring along the Castle trail. At 11:45 a great disturbance was noticed on the side walk where the branching to No. 10 occurred. Reds were mauling fellow reds, and it seemed as if there were difficulty in getting the line of march to turn to the right toward No. 10. By 12:30 enough ants had been deflected to the new trail branch to bring back a line of pupae from No. 10, but the main Castle trail had not been abandoned. At 5:15 the Castle column suddenly uncovered Nest No. 11, which surprisingly enough lay beneath the regular trail which had been traversed for weeks. Evidently it had been well plugged. At 5:38 the first pupae were brought out, and now ants were carrying pupae from two nests (Nos. 10 and 11). The ants of the remaining Castle trail, still exploring in the grass beyond, had meantime located Nest No. 12; and by 5:45 they were bringing pupae

Trails		WALK NEST					DOCK NEST			
		Memorial	Castle	Center Island	Lower	Boat House	Pump	Bank	Dining Hall	Cedar
8- 1-'39	A. M.	E		P			P			
	P. M.	No. 5					E			
8- 2-'39	A. M.		No. 6	E				E		
	P. M.		E					No. 20		
8- 3-'39	A. M.	E						E		
	P. M.				No. 7			No. 21		
8- 4-'39	A. M.				E					
	P. M.							E		
8- 5-'35	A. M.							E		
	P. M.							E		
8- 6-'35	A. M.	E			No. 8					
	P. M.	E			P					
8- 7-'39	A. M.	No. 9			P					
	P. M.				E				E	
8- 8-'39	A. M.	E			E				E	
	P. M.	E	E		E				No. 22	
8- 9-'39	A. M.	E							P	
	P. M.	E	E			E			P	
8-10-'39	A. M.	E	No. 10		E				P	
	P. M.		No. 11 No. 12						E	
8-11-'39	A. M.		P						E	
	P. M.		No. 13 No. 14						No. 23	
8-12-'39	A. M.		P			E			P	
	P. M.		P			No. 15			E	
8-13-'39	A. M.		E			P			E	
	P. M.		No. 16					E		
8-14-'38	A. M.		P			E		E		
	P. M.		P							
8-15-'39	A. M.		P							
	P. M.		P				E			
8-16-'39	A. M.		P				E			
	P. M.		P							No. 24
8-17-'39	A. M.		P							E
	P. M.		P							No. 25
8-18-'39	A. M.		P							P
	P. M.		E							E

An eighteen day record at the twice dialy forays of two *Formica sanguinea subintegra* colonies.
Numbers 5-25 indicate *Formica fusca subserica* nests raided (see map). Each nest raided implies a successful exploratory foray plus a period of plundering.
P=Continued plundering of a nest after the initial entrance and looting.
E=Exploratory forays which did not succeed in locating nests.

from it. Thus in one day three nests were discovered and by late afternoon pupae were being brought from all three over the Castle trail. As might have been predicted, after such a successful day, ants were still on the trail at 7:45 in the dusk and chill of the evening.

These permanent trails were not tried out and abandoned successively but were returned to, time after time, throughout the season as can be seen by the chart which shows daily records for part of the summer.

Numbers of Ants on the Trail.—The number of ants on a trail at any one time varies tremendously, as does also the proportion of those leaving the home nest and those returning to it. A set of counts made on a Dock Nest trail may be considered typical. At 3:30 the afternoon raid was just beginning along an old trail and was densely populated with a steady stream of ants. The line was narrow, 6 or 8 inches wide, and was progressing about 14 feet in 5 minutes. In half an hour the column had progressed and spread out into the typical exploratory one four feet wide, with a fan-shaped end over eight feet in width. Thirty-five minutes after the raid began, many ants in the front were starting to return to the home nest; evidently a nest that might be raided had been located, and individuals were returning apparently for reenforcements. At this time only 61 ants were going out while 133 returned to the home nest during a five-minute period. Forty-five minutes after the retreat began the direction of flow had changed once again and many more ants were going out than back. The line had now ended beneath a cedar tree where the raiding ants were exploring all crevices. Within an hour, pupae were being carried from the nest discovered beneath this cedar, and by 6 P. M., no more ants were coming from the home nest, but a steady stream were returning to it. At this time, in 5 minutes, 163 crossed the line, 20 of which carried pupae. At 6:40, in 5 minutes, only 105 ants returned home, 3 carrying pupae; however, this still made a fairly good column, a steady stream of ants moving rather slowly.

At no time did all the ants returning home carry loot. A strong line, at the height of looting activity, was checked for number. The column was narrow (7 inches across) with little obstruction, so that ants were moving steadily and rapidly. In 15 minutes, 376 ants were counted going toward the nest being raided, while 392 ants were counted returning home from it. Of those returning 136 were carrying pupae, 26 had larvae, and one black adult was being transported. Thus fewer than 42% of the returning ants were carrying brood.

The speed of individual ants carrying pupae was recorded for intervals of one minute. This varied from 24 to 36 inches traveled per minute. The distance traversed depended largely on whether the individual found a bit of bare ground or whether it had to manipulate the pupa through impeding grass stems. The ants did not follow a rigid path, but each picked its own course within the width of a foot.

Nests Raided.—The numbers of nests raided were few in comparison with the numbers of forays made. In 1939, between July 14 and August 20, the Walk Nest made 42 observed forays and raided 16 nests. The Dock Nest, in this period, made 36 observed forays and raided 10 nests. Distances traveled to these nests varied considerably, the

farthest being 210 feet, while others were 165, 130, 76, and 40 feet. There was no indication of "territory" in which each *sanguinea* colony was privileged to loot, except in so far as the nests were of sufficient distance apart so that their lines of raid never crossed each other. Occupation of a raided nest did not usually extend over many days. From 24 records it was found that occupation of a nest lasted only one day in 8 cases, and extended over 2 days in 12 cases; in the other four raids occupation lasted 3, 4, 6, and 7 days, respectively.

Duration of Raiding Periods.—At Gibraltar Island, the *sanguinea* raiding season begins in July, the earliest one observed being that of July 7, 1933. Since the raids are very conspicuous on the island and are looked for each year the first observed raid is probably the first actual raid, or within a few days of it. Records of first observed raids are as follows: 7-21-29, 7-20-30, 7-15-31, 7-7-33, 7-29-34, 7-17-35, 7-21-37, 7-14-39. In some cases nests were known and watched a number of days before the beginning of the raiding season. From these observations, it has been found that there is very little surface activity during this early summer period. *Fuscas* come in and out foraging, and occasionally a *sanguinea* comes up to deposit an empty cocoon, for this is the time of the maturing of the winged forms; otherwise there is nothing to draw attention to the nest.

We have no records for the end of the raiding season. The latest observed forays were 8-27-37 and 8-20-39. Records ended here because the observers left the island, not because raiding activities had ceased. In fact, they had not even slowed down. It seems probable that the season lasts on into September, thus extending the raiding activities through a month and a half or two months.

Once raiding begins it continues daily, one raid each morning and one each afternoon, unless interrupted by rain. In 1939 there were two unexplained periods of suppressed activity (see chart) which affected both the Walk and the Dock Nest to varying degrees, but aside from these depressions and periods of rain, two forays left each nest every day. The noon lull was regular regardless of the weather. The length of time of morning or afternoon raiding activities varied considerably. If an exploratory foray was unsuccessful, activities ceased early, while if a new nest was discovered late in the afternoon the ants continued to transport loot until dark. If dark overtook pillaging ants in the captured nest, they remained there overnight and began their return journey early next morning. The morning line usually began between 9 and 10 o'clock, but it might commence as early as 7:15 or as late as 10:45. The morning raid was usually over by 12:30 or 12:40, but has been known to stop by 11:00 when unsuccessful, or to continue until 2:00 when pupae were being brought in. Afternoon raids varied a great deal in their beginning but usually started between 2:30 and 3:30. Ordinarily activity ceased by 7:00 or 7:15, but after a vigorous and successful raid, ants have been found on the trail in the dusk of the evening (7:45–8:00).

Effect of Temperature.—Raiding activities are not directly dependent upon temperature, as can be shown by a comparison of the two nests. Degrees of activity never correspond between the two; a strong raid

from one was often paralleled by a weak raid from the other. In a similar fashion one nest might start early in the morning or work late at night, while the other showed only scant, dilatory action. One interesting instance of "heat trap" occurred at the Walk Nest. On August 13, workers coming in from the Castle trail at 11:30 seemed to "go crazy" as they emerged from the shaded trail into the full sun of the nest area. Movements became fast and jerky; individuals climbed to the top of grass blades, then down and up others, thus avoiding the ground. They were running at random, carrying larvae, pupae, and black or red workers indiscriminately, and they did not seem to be able to get down to the nest openings. At noon the next day, the same peculiar process was repeated. This time, temperature readings were taken. The soil surface of the nest in the sun was 45° C.; one inch above the soil at the grass blade level, the temperature was 38° C.; in the shade near by, the soil surface was only 31° C. The ants on the trail were behaving normally in a perfectly normal temperature, but the soil of the sunny nest area had reached a temperature above their usual toleration, forcing them up onto the grass blades. Each time they came down to the ground to enter the nest they were forced up again away from the excess heat, until the whole area became covered with the returning ants unable to descend into the nest. However, within an hour most of the ants did succeed in penetrating the openings and the noon lull occurred as usual.

NUPTUAL FLIGHTS

The emergence of *sanguinea* males and females occurs near the beginning of the raiding season. The only series of flights which were accurately observed and recorded on Gibraltar were those of 1939. They showed quite clearly that flight does not occur in one splendid climax of masses rising into the air but may drag out over a number of days. The first flight was observed July 19, 1939, at 9:15 A. M., by C. H. Kennedy. This emergence at the Walk Nest was discovered when the first raiding trail of the year was traced back to the home nest. The morning had been clear and bright at 8 A. M., but by 9:15 a haze had covered the entire sky and a dead calm existed. The air was pleasantly warm. Activity was at its height when the nest was discovered. Numerous winged females were darting about on the ground or standing in clusters of two to five, at nest entrances or under bits of cover. By 9:30 some females were attempting to fly. They would climb grass blades, poise for a moment, then suddenly spread wings and take off. Some flew 150 feet at two to six feet above the ground before being lost to sight. Others rose almost straight up to the tree tops. Apparently the flight was at random, merely a dispersion out into the air. Almost all the winged ants leaving the nest were female; only four males were seen. During the activity many workers were present at nest openings and over the whole area of flight. By 9:40 the seemingly excited *sanguinea* and *fusca* workers were beginning to drag females back into the nest; by 10:00 the flight had decidedly slowed down and, by 10:15, it was practically over for the day, workers as well as winged females having gone back underground.

While this female flight was going on at the Walk Nest, a male flight was occurring at the Dock Nest. Here not as many individuals succeeded in flying, most of the male activity consisting in darting out one opening and back into another. Workers were numerous about the holes and seemed partly successful in preventing the males from leaving the nest.

The second day flight was checked more closely for its beginning and duration. The Dock Nest was active at 7 A. M., at which time males were seen clustered about the entrances. By 7:30 they were crawling up grass stems and flying away, while by 8:30 the flight was over. The Walk Nest was a little slower in getting started. Only a few workers were out at 8:30. The female flight was well under way by 9 and had quieted down by 10. A slight difference in activity was observed on the shady and sunny sides of the nest. The females emerging into full sunlight rushed directly up grass blades and flew immediately. Those in the shaded area loitered before flying and many were found secreted under dead grass clippings on the ground.

On the third day (7–21–39) the flights proceeded in the usual manner. At 7 A. M. the males of the Dock Nest were appearing at the openings, by 7:30 they were flying, and by 8:30 flight was over. At the Walk Nest the females did not begin to fly until 8:30 and a few were still emerging by 11 A. M.

Nests were not observed the next day but on July 23 the Walk Nest was found to be raiding, with no further signs of flight then or later. On July 24 a dilatory flight of males and a few females occurred at the Dock Nest and on July 27 a few winged females were seen to leave its entrances. Thus the flights dragged to a close.

Twice within the next week dealate females were seen near the large nests. In both cases workers were massed about them pulling them in all directions. They also seemed to be licking them. When the females were freed they were found to be unhurt, but evidently they were not allowed to re-enter the parent nest once they had left it.

A flight observed July 6, 1936, and numerous records of the occurrence of winged forms in the nests indicate that flight time has varied from about July 6 to August 3. It is interesting in this connection to find A. C. Burrill's record of a *sanguinea* flight which occurred at 9:30 A. M., August 6, 1900, at North Brookfield, Mass.

The tendency toward a "male" colony or a "female" colony is quite common in other species of ants as well as in the *sanguinea*. In the Gibraltar colonies it was noted that the female nest produced a few males and that a few females emerged from the male nest on each day of its flight. It would be interesting to understand the mechanism behind this.

NEST STRUCTURE

Talbot and Kennedy dug one nest (No. 2136 on South Bass Island) to the bottom and Kennedy has dug three other nests. As *sanguinea subintegra* seizes and occupies *fusca subsericea* nests and has the help of these black slaves in enlarging nests, the *sanguinea subintegra* nest probably follows the forms of *fusca* architecture. The authors have

made no close study of *fusca* nests but numerous field notes on *fusca* show similar nests except that *fusca* nests nearly always have more elaborate top galleries, as in our figure 2, than do *sanguinea* nests. We have found three types of nests: (1) Nests in crevices of massive rock; (2) Nests in flat surfaced clay soil; (3) Nests in *fusca* mounds. The only type of *fusca* nest not represented is the occasional one in a well rotted stump or log, a type which is scarce even in wooded areas.

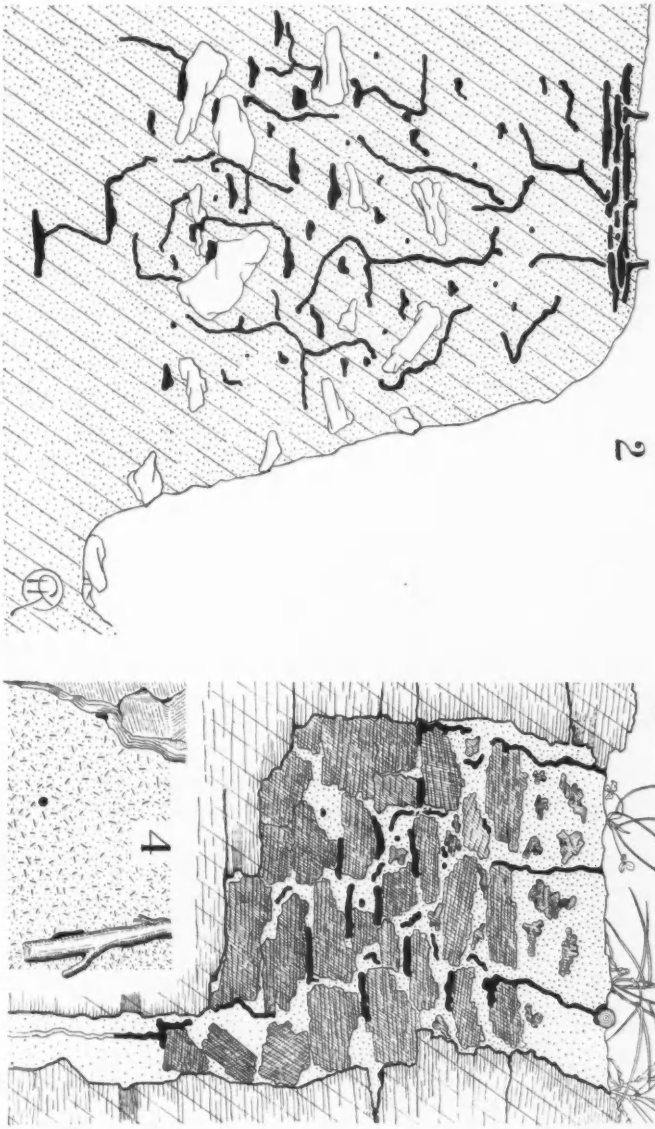
1. Nests in crevices of massive rock are the common type on Gibraltar Island. The first attempt to dig a *sanguinea* nest was made on one near figure 18 on the map. At ten inches deep the leading gallery passed down between two great blocks of stone that could not have been easily moved. After this disturbance the colony disappeared.

The second attempt was on a nest (Kennedy Coll., No. 1236 taken July 8, 1933) that would lie on our map between "No. 10" and the walk north of it. Dr. Norris D. Blackburn assisted in the excavation. A diagrammatic section of this nest is shown in figure 3, its three openings in figure 4. The longest opening was under the side of the surface root of a Celtis tree that shaded the area. The gallery leading down from it was 0.75 inch in diameter. The middle opening was 2.5 inches in diameter, that next the rock, 1 inch. The surrounding plants were largely blue grass. The nest was in the cleft between two outcrops of limestone. This cleft, about eighteen inches wide, was filled with the black soil of the island and numerous closely packed chunks of the native limestone. The top two or three inches were soil, then down to solid rock at 2 to 2½ feet, the filling was composed of soil with more than fifty per cent of its volume made of limestone chunks, one inch to one foot in diameter. There were no surface galleries (as in fig. 2). The three galleries led down eight to ten inches where the first chambers were found. Fifteen to twenty chambers were found from this level to a depth of over two feet. The greatest number were in a zone between the depths of twelve and eighteen inches. Chambers varied from 1 to 4 inches in length, 1 to 1.5 inches wide and were usually about 0.75 inch high. The position was generally just under the edge of a stone. However, the larger stones did not have nests under their central areas. The lowest chamber had a gallery that led straight down from it into the narrowed cleft between the limestone rocks.

This proved to be a queen nest. The many winged queens, of which one-third were callows, were found scattered variously in chambers at all levels. Only three males were found. There were few pupae. Ten black slaves occurred for each *sanguinea* worker. The red workers were much more solicitous in caring for the brood than were the black workers.

EXPLANATION OF PLATE II.

Figs. 2–4. *Formica sanguinea subintegra* nests. 2. Diagrammatic section of nest (type in deep well drained soil) collected on Toll Hill, Adams County, Ohio. This shows the unusual chimney-like nest openings, and the subsurface or top galleries common to *fusca* and many other ant nests. 3. A nest of the type in a broad cleft of massive limestone, collected by Blackburn and Kennedy on Gibraltar Island. 4. The openings of nest shown in fig. 3.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Our figure 7 shows a map of the Walk Nest of figure 1. It shows the short paths which lead for a foot or two from the larger openings. These paths escape notice easily as they are generally arched over by grass. During 1939 there was *never any debris* about this nest. Even pupal cases were carried out far beyond the edge of the nest and were scattered. In figure 7 the areas about the nest openings free of debris are shown stippled.

2. The first nest taken in deep soil was discovered by Professor A. C. Cole and Kennedy, April 17, 1931, on the bank of a road running up the side of Toll Hill, southeast of Peebles, Adams Co., Ohio. On the edge of this bare, three-feet-high clay bank the top of the nest covered an area two by five feet. This area was a low clay mound averaging 4 inches high and bare except for an occasional spray of grass. Scattered over it were a dozen or so of the usual funnel openings and among them were a few clay "chimneys" two inches tall (fig. 2). It was the only nest Kennedy has ever seen with chimnied openings. Except for the chimneys, this low, clay-dome type of nest surface is characteristic of *Formica fusca subsericea* nests in the hills of southern Ohio. Such structure occurs on those well defined slopes where the water-table does not approach the surface by a vertical distance of many feet. This low dome-type of *subsericea* nest has been observed by Professor C. A. Dennis and Kennedy in the hills of Tennessee. We have seen such bare clay areas ten feet in diameter though two or three feet is the usual size.

The first one to two inches was irregularly chambered but the next six inches was a mass of interlocked flat brood (?) chambers (fig. 2). Below this, level galleries ran downward in all directions connecting here and there with irregular chambers below. In the top foot of the side of the nest there were ten *fusca* workers to each *sanguinea* worker. The nest was then recovered to be opened at some later date in the hope of collecting winged forms.

On August 5, 1932, Professor C. A. Dennis and Kennedy dug this Adams County nest to below its last bottom chamber. The bottom cell was 36 inches below the top surface. Our notes indicate the first four inches were with flat interlocked chambers in which were a few *fusca* workers. No mention is made of the curious clay chimneys found in April of the preceding year on this same nest. Next below the surface brood chamber irregular galleries ran down to about 24 inches, these averaging six inches apart and wandering in all directions. They varied in diameter from that large enough to pass one ant, to those the size of a lead pencil. Chambers one to two inches in diameter

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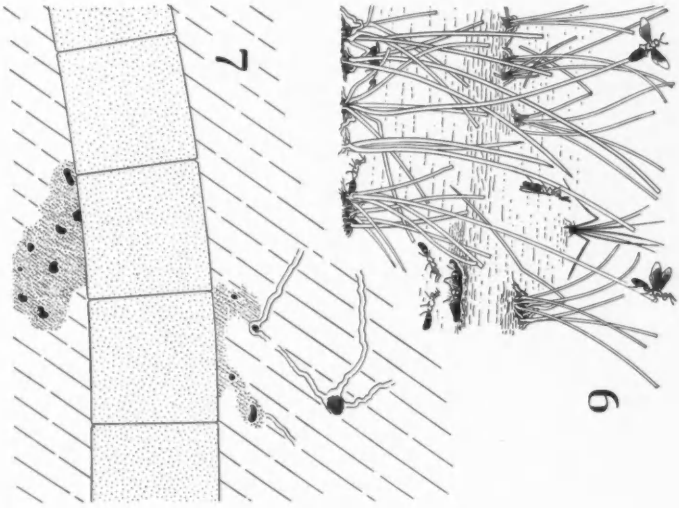
EXPLANATION OF PLATE III.

Fig. 5. *Formica sanguinea subintegra* nest in a *Formica fusca subsericea* mound on the Bronson farm, Kipton, Ohio. A mound associated with a high water table.

Fig. 6. Diagrammatic sketch showing the meager nature of flight activities in a *sanguinea* colony, in this case a queen producing nest.

Fig. 7. Sketch map of surface openings of the "Walk Nest" on Gibraltar Island. Stipple indicates areas free of debris. Short paths are shown by parallel lines radiating from the blackened nest openings.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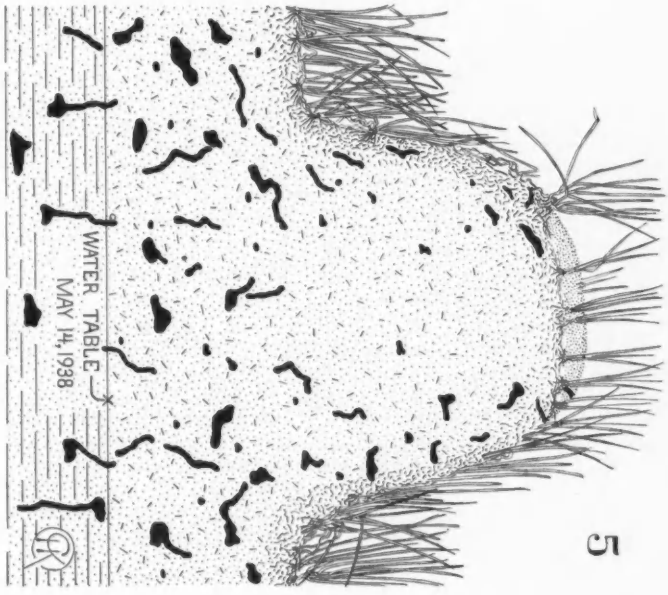
WATER TABLE
MAY 14, 1938
5

were most numerous in the area between 24 and 30 inches down, at which level chambers occurred 2 to 6 inches apart.

The nest queen was found at the 24 inch level. There was much worker brood (larvae and pupae) but no winged forms. There were about ten black slaves to each red slavemaker. A nest (No. 907) of a species of red Aphenogaster was found in some loose leaves on the top of the *sanguinea* nest.

The second nest of this type in normal deep clay was dug by Talbot and Kennedy, July 27, 1935. It was located on South Bass Island in one of the strips of open glade in the woods. At the surface a bare place in the blue grass three feet in diameter gave evidence of the nest. There was one active entrance which was on one side of the bare area. On digging, it was found that the nest extended down 27 inches and was wider than the bare area of ground above. Near the surface cross galleries were common but lower down galleries were usually vertical. Ants were packed tightly into many chambers and in galleries. With the workers were larvae, naked and covered pupae, many males and a few winged females. The temperature down two feet in the moist clay was 70° F. while at the surface it was 98° F.

3. Nests in mounds were found four times by Kennedy. (Nos. 2945 and 2947, Kennedy Coll., along roadside east of Westerville, Ohio, 2950, on the Fril Bronson farm one mile south of Camden Center, Lorain Co., Ohio, and an unrecorded nest on a game refuge south of Camden Center.) In each case the *sanguinea* mound was associated with mounds of *fusca subsericea*. In each case the mounds were in flat country where the water table came to the surface during the wet season (winter and early spring) and where the mound appeared to be a necessity to keep from drowning.

Our figure 5 is a diagram of the *sanguinea subintegra* nest on the Bronson farm. This was dug May 14, 1939, by Kennedy and his son Bruce. This bluegrass-covered mound was one of 70 similar mounds located along the west edge of an oak-hickory woods in the perfectly flat old lake bed of the Camden Center area. The 70 *fusca subsericea* mounds were each opened and inspected enough to be fairly certain that no red ants were present. It was the only *sanguinea* mound found. The nest was dug to one foot below the surface when free water was encountered though the ant galleries plunged vertically into this drowned area. We dug out chunks of clay six inches below the surface of the water but found no drowned or live ants in the submerged chambers. There were few chambers in the center of the mound. The greater number were between the surface of the ground and the water table. These lower chambers spread beyond the perimeter of the mound above. In the south wall of the nest-mound a considerable nest of Crematogaster occurred.

The colony was large with ten black slaves to one red worker. In some of the lower chambers were clutches of eggs. No larvae or pupae were found. No drowned or dead ants were found. Thus, as no larvae were found at this early date we can infer that the many workers present were from the 1938 season. We can infer further that in some manner the hibernating ants were able to escape drowning by the rising water table. They must have gone into hibernation the fall before when the water table was much lower.

The lower chambers were slippery wet yet this condition did not appear to bother the red and the black workers.

We can state some general features of *sanguinea* nests. The nests dug to what was believed to be the bottom were from two and a half to three feet deep. The chambers were irregular in shape and varied up to four inches in length, with a width of 1 to 1.5 inches and a height of 0.75 inch. The area of greatest number of cells is at middepth of the nest. They follow the local architecture of the slave species, *fusca subsericea*, in that in such territory as Gibraltar Island where drainage is perfect no mound is made and no top brood chambers are constructed. The ground is unusually dry and warm enough that the brood is reared in deep chambers. In flat, wet, undrained country, as in the glacial lake bed about Camden Center, they make use of mounds as does their prey, *fusca subsericea*.

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PEDIGREES AND CHECKERBOARDS, by E. FLETCHER BARROWS. 233 pages. 1940. 8.5 x 10.75 inches. Planographed by EDWARDS BROTHERS, INC., Ann Arbor, Mich. Price $1.50.

This is a rather curious book, consisting as it does of over 100 pedigree diagrams illustrating hereditary transmission in many animal and plant species familiar to the geneticist. It is, therefore, intended as a workbook for courses in genetics, and represents, to the knowledge of this writer, the first of its kind. The entire book consists of pedigrees charted with the customary squares and circles with phenotypes attached and with blanks for genotypes to be filled in from information as to the inheritance of the particular traits which is supplied in a key. Several examples of almost every kind of genetic trait are provided in the nine series of problems, including pedigrees involving linkage, parthenogenesis, polyploidy, self-sterility, and so on.

Exercises involving the manipulation of gene symbols are, of course, extremely helpful in acquainting the student with the mechanics of Mendelism, and for this sort of training the present workbook is very satisfactory. Much more, however, remains to be done in compiling a comprehensive workbook for genetics which might include the aspects of physiological genetics, cytology, genetic equilibria, inbreeding coefficients, quantitative inheritance, breeding indices, etc., likewise in the form of unworked exercises.—C. W. C.

THE BIOLOGY OF COMPSOMYIOPS WHEELERI (HOUGH) AND DESCRIPTION OF THE LARVA

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Although *Compsomyiops wheeleri* (Hough) has not been found to be of economic importance, information concerning the species is of interest to workers studying blowfly populations. *C. wheeleri* was described from specimens taken in California and has since been found in Arizona, New Mexico, Texas, and Mexico. The distribution probably extends into other of the western mountainous States.

SEASONAL DISTRIBUTION

Seasonal distribution in Arizona.—Adults of *Compsomyiops wheeleri* were taken in survey traps at Alpine, Pine, Prescott, and Flagstaff, which are in the mountainous sections of the State, during July, August, and September. Trapping records showed that they first appeared at Canon (P. O. Bumble Bee) and Wickenburg along the lower escarpment in October. The flies were not present in the trap catches at Tempe until November. *C. wheeleri* remained active throughout the winter in the warm valleys of southern Arizona, and was present until April at Tempe, and until May at Wickenburg and Canon. At Nogales adults were present in the trap catches during all months except July and August.

Compsomyiops wheeleri never became numerous in any of the irrigated areas even though present in relatively large numbers in adjoining areas. During the first half of March, 1937, *C. wheeleri* made up 1.6 per cent of the blowflies taken at Granite Reef, about 20 miles above Tempe on the Salt River. *C. wheeleri* was not taken in the Tempe status trap, which was in operation during the same period. On April 7, 1938, 1,248 adults were taken from a trap at Granite Reef, and with this population in the adjoining desert the species was represented in the catch of the Tempe status trap.

The largest catch of *Compsomyiops wheeleri* was at Canon for the two weeks ending March 30, 1938, when 3,072 flies were taken. They constituted 1.7 per cent of a 16-quart catch of flies which was predominantly *Phormia regina* Meig.

Seasonal distribution in Texas.—*Compsomyiops wheeleri* was collected and identified from blowfly trap catches in Texas in 1937, 1938, and 1939 by W. L. Barrett, Jr. The species was found in the following localities: Brackettville, Castle Canyon, Langtry, Sanderson, Brewster County, Presidio, Marfa, Fort Davis, Balmorhea, Fort Stockton, Sheffield, Ozona, Junction, San Saba, Llano, Fredericksburg, San

Marcos, Gonzales, Three Rivers, Alice, San Perlita, Laredo, Catarina, Crystal City, D'Hanis, and Sabinal.

Compsomyiops wheeleri was collected in Texas the first time by A. W. Lindquist at Uvalde from a blowfly-status trap between December 15 and 31, 1936. During the spring of 1937, *C. wheeleri* was found to be generally distributed over southern and western Texas in March and April. In June, 1937, the species was taken at Marfa, Fort Davis, and Fort Stockton, but nowhere else. It was not found in blowfly trap catches anywhere in Texas in July and August, 1937. The species again appeared at Fort Davis in September and at Marfa, Balmorhea, Fort Stockton, and Sheffield in October. During December the fly was definitely established to have been active only at Fort Davis.

In 1938 the fly was taken in January at Marfa and Sheffield. By the first part of March records of activity had been obtained at Fort Davis and Balmorhea, which, like Marfa, are in the western portion of the State, and at Alice and Laredo in southern Texas. There is some indication that the infestation in southern Texas may result from migration from mountainous areas in Mexico instead of from western Texas. Traps were discontinued in the vicinity of Marfa, Fort Davis, and Balmorhea in the summer of 1938, but they were operated as far west as Sanderson and Fort Stockton, and over a large portion of western Texas. *Compsomyiops wheeleri* was not taken in any of the traps in 1938 after June 1. In 1939 *C. wheeleri* was generally distributed over southern and western Texas by the end of March.

The largest catch of *Compsomyiops wheeleri* ever recorded in Texas consisted of 228 of these flies, removed from a total catch of 16.5 quarts of this and other common blowflies at Sanderson from April 10 to 26, 1937.

Trapping records indicate that the species is confined to the more arid regions of the southwestern part of the State. It was never taken farther east than Three Rivers.

LIFE HISTORY

Breeding habits in Arizona.—In so far as is known, *Compsomyiops wheeleri* breeds only in carcasses. Gravid females were captured and eggs and larvae were taken from a dog carcass at Prescott in September, 1936. A gravid female was taken from a sheep carcass at Skull Valley in October. Captured gravid females oviposited readily on lean meat, and in some instances, where meat was not present, eggs were laid on the side of the vial in which they were kept. The total number of eggs per egg mass was not determined, but from 350 to 500 larvae developed from individual egg masses. Mature larvae have been collected from carcasses of cattle at Sonoita and Nogales during October and November, and from goat carcasses at Canon in March and April. Pupae have been taken from a cow carcass at Arivaca in April.

Breeding was not observed in southern Arizona during either the cold winter months or the hot summer months, though it probably does occur at these seasons under favorable temperatures. Females taken in the trap catches at Nogales during December, 1937, and January and February, 1938, were not gravid.

Life cycle.—Nine lots of flies were carried through from the egg to the adult stage. The life cycle was found to be similar to that of other related Calliphoridae. The eggs hatched in from 20 to 24 hours. The larvae matured in 5 days at a mean temperature of 69.5° F. and in 10 days at 58.5° F. Although moderately cool environment was favorable for the adults, the larvae did not develop until subjected to some warm temperatures, either natural or artificial. Eggs from a gravid female captured at Skull Valley, Ariz., in October, 1936, hatched in 24 hours, but owing to the cool temperatures to which the larvae were subjected for the four days following hatching they did not develop. The larvae developed rapidly when the temperature was favorable. The prepupal period was three to seven days when the mean air temperature was 69.9° F. Under cooler weather conditions a prepupal period of 15 days was recorded. The pupal period was 8 to 14 days at Tempe during October and November of 1936, when the mean air temperature was 72.2° F. Pupae formed during December, 1936 and remained in the pupal stage 26 to 49 days. Larvae that pupated December 15, 1936, emerged February 2, 1937, surviving a mean temperature of 41.6° F. during January and a minimum temperature of 20° F.

DESCRIPTION OF THE LARVAL INSTARS

First instar.—The larva is of the usual muscoid shape. Its length ranges from less than 2.5 to 3.9 mm. Complete bands of spines encircle segments 2 to 9. On segment 10 the spines on the dorsum are absent or reduced in number, and on segments 11 and 12 they are restricted to the ventral and ventrolateral surfaces. Spines on the posterior margin of the segments are restricted to a single row on the venter of segments 7 to 12.

The spines are light to dark brown and possess a single point. The larger spines measure approximately 6 microns in length.

Three pairs of small tubercles are situated above and three pairs below the posterior cavity. The posterior spiracles, situated in the posterior cavity, consist each of two small openings or slits that appear fused below. The spiracular slits are not surrounded by a peritreme. Anterior spiracles are lacking.

The cephalopharyngeal mechanism is shown in figure 3. The length of the structure ranges from 0.29 to 0.33 mm., the average length of 10 specimens being 0.31 mm. The width ranges from 0.09 to 0.11 mm.

Second instar.—Larvae in this instar range in length from approximately 4 to 9.5 mm.—Spines on the various segments are distributed essentially as in the first instar. They are provided with 1 to 3 points, more often 2. A V-shaped group of spines located on the anal protuberance is similar to that found in *Cochliomyia macellaria* (F.), a related species. Although smaller, the relative sizes and positions of the tubercles bordering the posterior cavity and the general structure of the last apparent segment resemble those of the third instar.

The posterior spiracular plates each consist of two spiracular slits surrounded by an incomplete pigmented ring or peritreme. The greatest diameter of the plates (average of 10) is about 0.15 mm. The two anterior spiracles, situated one on each side and near the base of

segment 2, possess from 11 to 13 branches, with an average (based on 12 specimens) of 12.1 branches per spiracle.

The length of the cephalopharyngeal mechanism (fig. 5) averaged 0.76 mm. in 10 specimens, with a range of 0.72 to 0.81 mm.

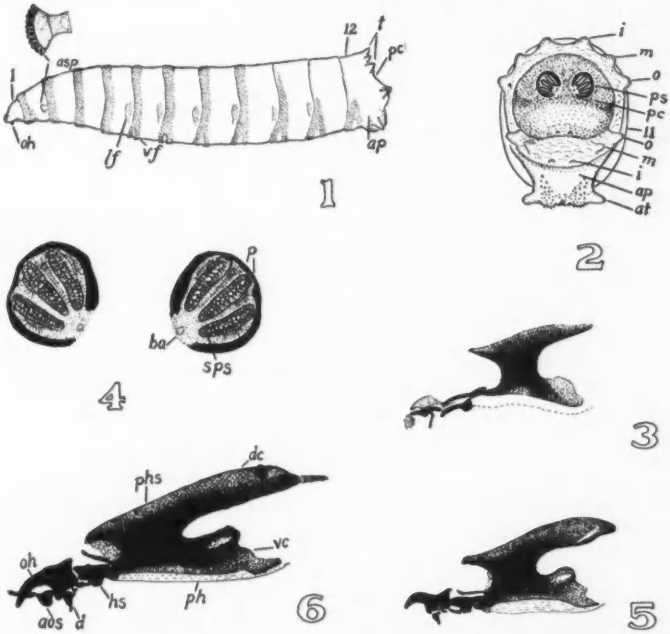

Figure 1. Lateral view of mature third-instar larva, *Compsomyiops wheeleri* (Hough), × 8. *l*, cephalic or first apparent segment; *oh*, oral hooks; *asp.*, anterior spiracle; *lf*, lateral fusiform area; *vf*, ventral fusiform area; *ap*, anal protuberance; *pc*, posterior cavity; *t*, tubercles on last apparent segment; 12, last apparent or twelfth segment. Fig. 2. Caudal view of last apparent segment. *i*, *m*, *o*, inner, median and outer tubercles on upper and lower margins of the posterior cavity; 11, eleventh segment; *ap*, anal protuberance; *at*, anal tubercles; *ps*, posterior spiracular plate; *pc*, posterior cavity. Fig. 3. Lateral view of the cephalopharyngeal mechanism, first-instar larva, × 200. Fig. 4. Posterior spiracular plates. × 86. *p*, peritreme; *sps*, spiracular slits; *ba*, button area. Fig. 5. Lateral view of the cephalopharyngeal mechanism, second-instar larva. × 100. Fig. 6. Lateral view of the cephalopharyngeal mechanism, third-instar larva. × 58. *aos*, accessory oral sclerite; *oh*, oral hook; *d*, dental sclerite; *hs*, hypostomal sclerite; *ph*, floor of pharynx; *phs*, pharyngeal sclerite; *dc*, dorsal cornu; *vc*, ventral cornu.

Third instar.—The general appearance of the larvae is as shown in figure 1. They range in length from 8.5 to 17 mm. The anterior margin of segments 2 to 9 is provided with completely encircling bands of spines. On segment 10 the belt of spines is incomplete on the dorsum, and on segment 11 the spines are generally restricted to the ventral or

ventrolateral surfaces. As in the first two instars, the posterior margin of segments is devoid of spines on the dorsum.

Anterior spiracles (fig. 1) consist of from 11 to 13 branches, the average number for 35 spiracles being 12.4. The posterior spiracular plates (fig. 2 and enlarged in fig. 4) are relatively large and are provided with a broad ring or peritreme. The greatest diameter of 10 spiracular plates ranged from 0.34 to 0.39 mm., with an average of 0.37 mm.

Three pairs of tubercles are situated on each of the upper and lower margins of the posterior cavity. On the upper margin the inner and outer pairs are approximately equal in size; the median pair is somewhat smaller. The inner pair is separated by a distance that is less than two-thirds the distance between the inner and the outer tubercles on each side. The outer pair of tubercles on the lower margin is larger than the median; the inner pair is greatly reduced. The anal protuberance possesses two prominent tubercles. The spines on the anal protuberance are arranged in a V-shaped group, a characteristic also of the larva of *Cochliomyia macellaria*.

The cephalopharyngeal mechanism (fig. 6) ranges in length from 1.5 to 1.68 mm., with an average of approximately 1.6 mm. In general appearance it closely resembles that of related genera, *Cochliomyia* and *Phormia*, however, one striking difference is the presence of an accessory oral sclerite (*aos*) which is not present in either of these genera.

Systematic relationship.—The absence of a distinct and well-developed "button" in the posterior spiracles of the third-instar larva of *Compsomyiops wheeleri* is a characteristic common to such genera of Calliphoridae as *Cochliomyia*, *Protophormia*, and *Phormia*. Other characteristics of *C. wheeleri*, such as the appearance and distribution of spines and the general appearance of the cephalopharyngeal mechanism, indicate close relationship to the genera mentioned.

The larva of *Compsomyiops wheeleri* is most likely to be confused with that of *Cochliomyia macellaria*. The distribution and appearance of the spines are almost identical. However, the species may be readily distinguished in the third larval instar by the presence of an accessory oral sclerite (*aos*, fig. 6) and by the relative size and position of the tubercles situated on the margin of the posterior cavity. The presence of an accessory oral sclerite in the third-instar larva of *C. wheeleri* will distinguish this species from related species of *Cochliomyia*, *Phormia*, *Protophormia*, and *Lucilia*. *Calliphora* and *Cynomya* also possess the so-called accessory oral sclerite, but the presence of a closed peritreme in the posterior spiracles, forming a distinct button, will immediately differentiate the third-instar larvae of these species from those of *C. wheeleri*. The closed posterior spiracle is also characteristic of the third-instar larva of *Lucilia*.

The first and second larval instars of *Compsomyiops wheeleri* are more difficult to distinguish from related Calliphoridae; however, specific diagnostic characteristics are apparent, such as distribution of spines, structure of the cephalopharyngeal mechanism, and relative sizes and position of the tubercles bordering the posterior cavity.

WATER VAPOR AS A FACTOR AFFECTING THE SURVIVAL OF EPHESTIA ELUTELLA AND LASIODERMA SERRICORNE AT REDUCED PRESSURE

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Until comparatively recent years the study of the effect of artificially reduced pressures on insects has been neglected, although Robert Boyle (1670) made observations on the activity of insects and other animals exposed in partial vacuum and was apparently the first to record notes on the effects of lowered pressures. Following his observations, many years, even centuries, elapsed before entomologists began to pay serious attention to this factor. Cole (1906) carried out some experiments with the rice weevil (*Sitophilus oryza* (L.)) in a reduced atmosphere, and since that time several investigators have made studies of this question. The data which have been accumulated and presented indicate that the investigators entertain different concepts, in some cases opposite in nature, on the effect of reduced pressure on insects.

The purpose of this paper is to present data on the evaporation or absorption of water vapor and the mortality that resulted from subjecting the tobacco moth (*Ephestia elutella* (Hbn.)) and the cigarette beetle (*Lasioderma serricorne* (Fab.)) to artificially reduced pressures in dry and in water-saturated atmospheres equivalent to an absolute pressure of 2 inches of mercury. Data are also presented to indicate the effect on water loss or gain and on mortality that occurred from the addition of oxygen, carbon dioxide, or nitrogen to the dry and to the water-saturated atmospheres.

PLAN OF EXPERIMENTS

The insects were exposed in dry and in water-saturated partial vacuum, and the loss or gain in water content, as evidenced by the loss or gain in weight during the exposure, and the resulting mortality were determined. Following the studies in partial vacuum of normal air others were made in dry and in water-saturated partial vacuum in which the percentage of oxygen, carbon dioxide, or nitrogen was increased beyond the proportions normally occurring in air.

For the studies using increased proportions of dry gases the pressure chamber containing the test insects was supplied with about 50 grams of anhydrous calcium sulfate and then exhausted to an absolute pressure of 1 inch, after which a quantity of the particular gas sufficient to raise the pressure 1 inch (i. e., to give an absolute pressure of 2 inches) was introduced. In the studies of the water-saturated gases a small vessel having as large an area of evaporation as was convenient was placed in the reduced-pressure chamber, after which the atmosphere was exhausted. Since the pressure exerted by water vapor at the temperature (80° F.) at which these experiments were conducted is approximately 1 inch, the pressure in the chamber could not be reduced lower than this figure. If upon the cessation of pumping the pressure in the chamber did not rise, the atmosphere in the chamber was regarded as being composed of water vapor. When a constant pressure of 1 inch was established, a quantity of the gas under study sufficient to raise the pressure an additional inch, or to a total absolute pressure of 2 inches, was introduced into the chamber. It follows that slight differences in the total quantity of gas present in the wet and dry chambers existed, although the pressures were the same.

Glass desiccators, each having a capacity of 8.94 liters, were used as reduced-pressure chambers. The vacuum pump was enclosed in a container of oil and was capable of reducing the absolute pressure to less than 1 millimeter. The vacuometer used was of the mercurial type and was calibrated to record absolute pressure directly.

For the purpose of clearly showing the relative mortalities produced, an 8-hour exposure was employed, because at this exposure the percentages of mortality in both the dry and water-saturated atmospheres were below 100 and above 0 per cent.

Larvae of *Ephestia elutella* and larvae and adults of *Lasioderma serricorne* were used as test insects. The lots of insects were weighed immediately before and after each experimental exposure. All larvae of both species were well grown, and adults of *L. serricorne* were from 1 to 4 days old.

The effect of the different atmospheres on the insects was gauged by two criteria: First, the percentage loss or gain in weight during the exposure, which served as an index to the evaporation or absorption of water; and, second, the percentage mortality resulting from the treatment.

Experiments to serve as controls were carried out simultaneously at atmospheric pressure, the insects being exposed unprotected for a period of 8 hours to a temperature of approximately 80° F. and a relative humidity ranging from 80 to 95 per cent. The loss in weight and the percentage mortality resulting were negligible. For example, larvae of *Ephestia elutella* showed a loss of 2.66 per cent in weight and a mortality of 2 per cent, and adults of *Lasioderma serricorne*, 1.67 per cent in weight with mortality at 1.29 per cent. Other stages of these two insects showed similar losses in weight and percentages of mortality.

RESULTS

The results of the experiments carried out are given in Table I. In comparing the effect of dry and water-saturated air on the test insects it was found that evaporation and mortality were considerably greater in the dry than in the water-saturated air. Boyle (1670) found that if the exposures were long enough and the pressures lowered sufficiently certain species of insects were killed. Back and Cotton (1925), while listing the lethal effect of reduced pressures, observed that the exposure necessary to produce complete mortality varied with the species and stage of species used. Lutz (1929), however, was the first to demonstrate that insects at reduced air pressures lost moisture by evaporation more readily than at normal atmospheric pressures.

TABLE I

CHANGE IN WEIGHT AND MORTALITY OF *Ephestia elutella* AND *Lasioderma serricorne* CAUSED BY AN 8-HOUR EXPOSURE TO DRY AND WATER-SATURATED AIR AND OTHER GASES AT AN ABSOLUTE PRESSURE OF 2 INCHES OF MERCURY, RICHMOND, VA., 1937

Species and Stage of Insect	Insects in Tests	Change in Weight*	Mortality	Insects in Tests	Change in Weight*	Mortality
	Number	*Percent*	*Percent*	*Number*	*Percent*	*Percent*
	DRY AIR			WATER-SATURATED AIR		
E. elutella larva	25	—48.30	88.0	50	—1.28	2.00
L. serricorne adult	217	—43.70	95.85	313	—4.87	6.41
	DRY OXYGEN			WATER-SATURATED OXYGEN		
E. elutella, larva	25	—24.67	48.00	.....	.....	.....
L. serricorne, larva	400	—23.45	6.50	400	+0.84	4.50
L. serricorne, adult	368	—36.06	67.54	235	—4.77	27.12
	DRY CARBON DIOXIDE			WATER-SATURATED CARBON DIOXIDE		
E. elutella, larva	25	—36.33	96.00	.....	.....	.....
L. serricorne, larva	400	—51.69	96.25	400	—1.75	4.50
L. serricorne, adult	381	—45.84	97.54	308	—0.34	39.96
	DRY NITROGEN			WATER-SATURATED NITROGEN		
L. serricorne, larva	200	—44.21	98.50	200	+1.82	0.50
L. serricorne, adult	92	—41.54	98.91	107	+0.98	43.93

*An increase in weight is denoted by a plus (+) sign; a decrease by a minus (—) sign.

Dry oxygen in the reduced-pressure chamber seemed to prevent to some extent loss of water through evaporation and to keep the mortality at a lower figure, and water-saturated oxygen considerably reduced the loss of water and the percentage of mortality as compared with dry oxygen. Cotton, Wagner, and Young (1937) suggested that the increased efficiency of fumigants when used at reduced pressures was due to the reduction of the total amount of oxygen as well as to increased penetration of the fumigant. Later (1937*a*) these investigators elaborated their theory of oxygen deficiency and presented data to prove their former suggestion. The data in the present paper show that increasing the total amount of oxygen in the chamber prolonged the life of the insects and in the dry chamber reduced evaporation. Owing to the nature and limited scope of the experiments reported here the relative importance of oxygen deficiency and the water vapor present in the chamber may not be evaluated.

A comparison of the data on dry and water-saturated carbon dioxide shows that this gas when dry permitted exceedingly higher losses of water and caused exceedingly higher mortalities than resulted from water-saturated carbon dioxide. The effect of carbon dioxide on insects at reduced pressure has not been investigated previously, except that Cotton and Young (1929) presented data to show that the addition of carbon dioxide to certain fumigants in vacuum treatments increased their insecticidal efficacy. Jones (1935) published data to show that carbon dioxide is itself a good fumigant when used with a smaller proportion of an activating gas, it being held that the two gases acted synergistically. From data presented in this paper it may be seen that carbon dioxide in a dry vacuum might be easily mistaken for a toxicant, but the dry vacuum is not often encountered in actual fumigation practice.

In dry nitrogen as compared with water-saturated nitrogen the insects lost considerable water and showed higher mortalities in the former, and in the latter showed gains in water content and suffered greatly reduced mortalities.

A comparative study of the effect of air, oxygen, and nitrogen in a dry chamber at the reduced pressure seemed to indicate that all these except oxygen caused high mortalities, oxygen appearing to prevent evaporation to some extent and to reduce the mortality. Loss in weight caused by the different gases to a particular stage was not uniformly correlated with percentage of mortality.

A study of the evaporation and mortality caused by air, carbon dioxide, oxygen, and nitrogen in a water-saturated chamber showed that none of these produced particularly injurious effects.

SUMMARY

The evaporation or absorption of water vapor and the mortality that resulted from subjecting *Ephestia elutella* and *Lasioderma serricorne* to artificially reduced pressures in dry and in water-saturated atmospheres equivalent to an absolute

pressure of 2 inches of mercury were studied. The results showed that in dry air water was lost and considerable mortality resulted as compared with almost negligible water-loss and mortality in the water-saturated air. The addition of oxygen to the dry chamber reduced water loss and the percentage of mortality. The addition of carbon dioxide or nitrogen to the dry chamber appeared not to alter greatly evaporation or percentage of mortality. Evaporation and mortality produced in the water-saturated chamber by the addition of nitrogen, oxygen, or carbon dioxide were not great.

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NOTICE TO AUTHORS OF ARTICLES WHICH HAVE APPEARED IN THE ANNALS

The Annals store room furnished by the Ohio State University is too crowded for further storage of the forty or fifty cases of cuts which have been used in printing the illustrations in the Annals. These are the property of the various authors who have paid for them. The Annals staff has stored and indexed these cuts to the year and issue, hoping they could be loaned for later use in other publications. About one such request for a cut or two is received in the course of two to five or more years. It is proposed to destroy them where the author is not enough interested to request them returned and to pay expressage for their return. The cuts of vols. I–X will be destroyed this fall, or we will be glad to give these cuts to each author requesting his, or to any responsible institution after authors have had the present opportunity to claim their own. We ask for any such blanket proposition.

We dislike very much to destroy the cuts but storage would cost from four to eight dollars per month which the Annals cannot afford to pay.—*The Managing Editor.*

THE GENUS PLUSINIA

(Lepidoptera, Thyatiridae)

Wm. T. M. Forbes,
Department of Entomology,
Cornell University,
Ithaca, N. Y.

In 1936, I wrote[1] of the Thyatiridae: "The most serious omission is probably *Plusinia*, which is represented by the female type in the British Museum, and *Mimopsestis* (*Spilobasis*), also, I believe, represented only by the type. If they are Thyatirids at all they should show light on the origin of the whole group when studied."

On a recent visit to the National Museum, three males of *Plusinia aurea* Gaede were noted among the undetermined Thyatiridae. The genus turns out to be as isolated as we had suspected, but is not directly ancestral to the rest of the family, in fact its superficial appearance hints it may lean somewhat to the more specialized Drepanidae. But it is unrelated to any of the other groups of the family, and I propose it be made a separate tribe, to be called *Plusiniini*.

This tribe may be formally defined as Thyatiridae with wings extremely broad, the fore wing decidedly less than twice as long as wide (unique in the family); antemedial and postmedial lines simple (unique); M_2 very low in both wings, the venation therefore "quadrifid" (as in Habrona only); antennae prismatic (like many Thyatiridae, but unlike Habrona); valves hardly longer than wide and perfectly simple, with much reduced costa (unique); clavus long, slender and articulated by a narrow base (unique); and internal chitinizations of penis represented by a smooth cap articulated to the tip of the sheath (unique).

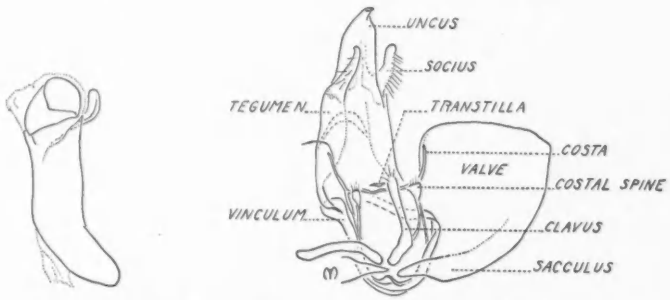
If, as we did in 1936, we take the consensus of Cimelia and Cyclidia to indicate the primitive condition of the family, *Plusinia* shows a remarkable number of primitive characters, more than any other known genera, in spite of its unique specializations of clavus, valve and penis. These are:

Eyes naked and not lashed; abdomen untufted; fore wing wide with apex distinct but not sharp and anal angle not tufted, smooth-scaled without a trace of basal tuft; accessory cell moderate, with R_3 and R_4

[1]Annals XXIX, 780, 1936.

most closely associated from its apex;[2] hind wing with Sc and R not fused. Uncus (see figure) strong and simple, broader than in Cimelia but narrower than in Cyclidia, clavus with few setae; valve not plaited; sacculus weak and unarmed; penis without external scobinations; spiracles of the same type, rather high with long tendinal process; last segment of abdomen short, without basal pockets.

The more normal Thyatiridae which share the largest numbers of these features are Bombycia, Saronaga and Habrona, forms already recognized as primitive and synthetic, and representing both main lines of development in the subfamily.



Male genitalia, viewed from the ventral side, opened up, with one valve omitted and penis figured separately. The wholly membranous juxta is not shown.

In general the resemblances are about equal in the two chief subdivisions and are closer to the main series of genera, from Bombycia to Miothyatira, than to the terminal Polyploca and Habrosyne groups.

I may note that the specimens are too poor to show vestiture characters plainly, but it can be seen that the vestiture is deep, of Thyatirid rather than Drepanid character, and that there are at least traces of the crested edge of tegulae and the truncate posterior tuft so common in the Thyatiridae. The collar vestiture is rather fine, but not so fine as in Thyatira and Habrosyne, more like that of Bombycia and Saronaga.

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[2]The open second accessory cell mentioned by Gaede is not indicated in our specimens and was evidently an individual freak. I have such a specimen of *Bombycia fluctuosa* (l. c., p. 793, note 15).

SOME MUD-DAUBING WASPS OF MEXICO AND THEIR PARASITES

PHIL RAU,
Kirkwood, Missouri

In a recent paper on the nesting habits of some social wasps in Mexico (Ann. Ent. Soc. Amer., 33:81-93, 1940), I give the details of a short trip to Mexico during February, 1939. For more information on the localities mentioned in the present paper, I would refer the reader to the introductory portion of that article.

Although many of the social wasps were alive and at work on their nests when the observations were made, that was not the case for the solitary wasps. February is evidently too early in the season for the solitary wasps to be abroad at the places which I visited; hence I had to be content to bring home what mud nests I could find, and await the emergence of any insects that might hatch from them, and later to gather any data I could by breaking open the nests and examining the contents.

THE WASPS

Most abundant among the mud nests from all places where I collected were those of the common yellow-legs mud-dauber, *Sceliphron caementarium*. The rounded mud nests of irregular shape were gathered chiefly from culverts under the highway, principally at a point about 40 kilometers north of Ciudad Victoria, State of Tamaulipas, and in some of the huts at Jacala, Hdgo., and at Tamazunchale, S. L. P. The nests were so badly infested by parasites that only a few of the original makers later emerged. These few, however, made it clear that the species was the same as the Missouri *S. caementarium*, with which I am very familiar. Even though several species emerged from these nests (and especially abundant was a nearly related steel-blue wasp), it was clear that all the nests had been made by the *Sceliphron* wasps. It is evident that a relationship exists between the two species, the yellow-legs and the blue wasp, which is very much the same as that described for the two analagous species in Missouri. *S. caementarium* in the United States makes her own cells and builds anew for each young, while *Chalybion cyaneum* (=*caeruleum*)[1] never builds cells of her own but steals those of the former species by breaking open the cells, throwing out spiders and egg, refilling with fresh spiders, depositing her own

[1]See account in Ann. Ent. Soc. Amer. 21: 25–35, 1928.

egg and finally resealing with mud made by moistening the side of the nest. In Mexico, the resealed cells of *Sceliphron* were so abundant that I at once suspected that the same relationship existed between the Mexican *Sceliphron* and some other wasp, even though the culprit may be different from the Missouri one. And so it was; the steel-blue wasp of Missouri is replaced by another of the same color, which may easily be mistaken for it, but which taxonomically is distinct, ***Chalybion zimmermanni***.

Chalybion zimmermanni Dahl. [G. A. Sandhouse]

I have been able to breed this species only from Mexican cells that have been replugged, sometimes with mud of an entirely different color, and sometimes with mud evidently gotten from other portions of the same nest. I find also that in all cells that have been resealed, and only those that have been so resealed, the characteristic cocoon of *Chalybion* with its tell-tale white, silky covering, and in cells that have not been resealed, I always find the shiny brown papery cocoons of the original inhabitant, *Sceliphron*.[2] Therefore the evidence is strong that in Mexico *C. zimmermanni* uses the nests of *Sceliphron*, and also that she uses mud to replug the opening when the cell has been refilled. Thus far we are sure she behaves like the Missouri *C. cyaneum* but whether she carries water to make mud out of the nest-wall, or gathers mud at nearby puddles for the plug, I do not know. Neither do I know whether she empties the cell and discards the prey of *Sceliphron*, or if she only finds and uses the empty cells after the original occupants have left, much as other species of solitary wasps use a hollow twig. An indication that this might be the case is seen in the fact that in one nest of *Trypoxylon mexicanum*, taken at Jacala, I found in two cells resealed with white plaster, dead adults of *C. zimmermanni*.

Since Hutson (Trans. Amer. Ent. Soc. 45: 203–227, 1919), while giving the locality data for *C. zimmermanni*, says there are no records of the habits of this species, I wish to add the following data. A dozen nests of *Sceliphron* gathered at Tamazunchale, and at a locality about 40 kms. south of Ciudad Victoria and at Jacala, gave forth about 25 adults of *C. zimmermanni* at Kirkwood, Missouri, between May 30 and June 25, 1939. It is not known if their emergence was influenced by the Missouri climate, or if in their own habitat the emergence dates would have been the same. It is of interest to know, however, that its near relative, *C. cyaneum* here in their native St. Louis habitat, had almost the same days of emergence (14 females and 15 males from 15 nests between May 28 and June 16). It is of further interest to know that nests gathered on the way to Mexico, at Sapulpa and Preston, Oklahoma, gave forth *C. cyaneum* during a similar period (11 females and 12 males from 10 nests between May 28 and June 25), but those taken in Texas, at the towns of Franklin and Artesian Wells, had earlier emergence dates (at Artesian Wells, 4 adults from 2 nests from May 2 to 12, and from Franklin, 5 adults from 2 nests, May 20 to 22).

[2]See Psyche, 62, April, 1915, for description of the two kinds of cocoons.

Trypoxylon mexicanum De Sauss. [G. A. Sandhouse]

(The Pipe-Organ Wasp)

This wasp makes a clay nest of parallel pipes very similar to those of our Missouri *T. politum*.[3] Nests which were taken at Jacala and Tamazunchale in February gave forth adults at Kirkwood during the following June. They were found in the culverts under the highway, and also in the huts of the natives, where they were often near the fireplace, and sometimes the clay had become baked so hard that the newly developed adult could not bite its way out, and died in the cell.

In one cell of a nest from Jacala, I found a dead earwig, *Doru lineare* Esch. [A. B. Gurney], but I do not know what its relationship to the original inhabitant may have been.

It is of interest to note that while no living members of this species were found in the localities mentioned above, when we reached the semi-tropical city of Cordoba, Vera Cruz, at an altitude of 2,800 feet, we found one mother *T. mexicanum* provisioning a cell in a nest of three cells. Two of these were sealed, and the third contained 3 spiders, two immature females of *Leucauge* sp. [E. B. Bryant], and one immature female *Eustalia fusco = vittata* Keys [E. B. Bryant]. In one of the old nests at Jacala, I found in an open cell two living spiders of *Eriophora* sp. [E. B. Bryant], but they may only have chosen this cell as a hiding place.

Trypoxylon texense de Sauss. [G. A. Sandhouse]

One dead specimen of *T. texense* was found in a cell of *T. mexicanum* taken at Jacala. This wasp makes no nest of its own, but uses discarded cells of other species of mud builders. Nests of *S. caementarium*, brought home from Sapulpa, Oklahoma, and Franklin, Texas, in February, gave forth a dozen adults of *T. texense* between June 3 and 20, 1939.

This species is extending its northern range, for I obtained a large number of them from Fish Lake, Illinois, about ten miles from St. Louis (Rau, Trans. Acad. Sci. St. Louis, 25: 442, 1928). These Illinois nests gave forth their adults from August 1 to 10.

Pachodynerus acuticarinatus Cameron [Jos. Bequaert]

This wasp used the old cells of the *Sceliphron* mud-wasp, bringing in mud for partitions and plugs. The nests were taken in native huts in Jacala, and many dead *Pachodynerus* were found in them. Here again the clay had become too hard for their escape. Several cells contained two mud partitions, which made three rooms for the young. All of these rooms were lined with a shiny, onion-skin membrane which, since the pupae were naked, I take to have been made in lieu of cocoons. The cells of other species of Eumenid wasps are only partly lined, but those of this species were completely lined. By careful manipulation, this lining could be pulled off the walls entire.

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[3]See Plate I, Journ. Animal Behav. 6: 27–63, 1916.

Ancistrocerus tuberculocephalus de Sauss. [Jos. Bequaert]

Four specimens of this wasp emerged at Kirkwood between March 22 and 28, from pipe-organ nests of *Trypoxylon mexicanum* which had been taken at Jacala in February. In another nest of *T. mexicanum*, a few days earlier I discovered, on opening some of the cells, a male and a female of this wasp fully matured and with wings spread ready to emerge. Whether the time of emergence was influenced by the St. Louis climate is not known, but it seems likely that the Mexican conditions of their growing period was the determining factor rather than the St. Louis conditions, since the local Eumenids emerge much later than March. The larvae of these wasps, like the aforementioned species, had spread a fairly substantial lining over the inner wall, so firm that, in its bag-like form, it could be removed entire from the cell. To find so substantial a covering was a surprise to me, since our local *Ancistrocerus* have almost entirely lost this habit. It would be of interest to know whether the habit is generally on the wane in the Eumenids, or whether climatic conditions influence the amount and thickness of this wall covering.

Monobia angulosa var. **nigripennis** de Sauss. [Jos. Bequaert]

A female of this species emerged from a cell of *Sceliphron* on June 20. The nest was taken from a culvert near Canon de Galeana, about 50 kms. north of El Limon, Tamaulipas. Two dead specimens, a male and a female, of the same species were found in another nest from the same place.

Dr. Bequaert writes that the typical *M. angulosa* has been bred in Paraguay from nests made in a stalk, where the cells were divided by mud partitions. "The habits are evidently the same as those of our *M. quadridens*."

THE PARASITES

Chrysis (Trichrysis) mucronatus Lep. [G. A. Sandhouse]

Two dead specimens of this cuckoo-bee were found in cells of a nest of the pipe-organ wasp, *Trypoxylon mexicanum*, taken at Jacala. Evidently they were parasitic on these wasps.

Chrysis sp. [G. A. Sandhouse]

Three dead cuckoo-bees were found in the cells of *Sceliphron* nests taken in culverts 40 kms. south of Victoria. In addition, two of the same emerged at St. Louis on June 25 and 29, 1939. On May 21 another specimen, emerged from a pipe-organ nest of *T. mexicanum* from Jacala, but in this case it was parasitic on an Eumenid wasp that had occupied the old cell.

Photopsis sp. No. 1,438 [G. A. Sandhouse]

One specimen of this parasitic wasp hatched from a cocoon of *T. mexicanum* from Jacala, on May 14, 1939.

Sphaerophthalma auripilis Blake [G. A. Sandhouse]

One specimen emerged May 9 from a mud-dauber's nest taken at Moore, Texas. It was parasitic on the wasp *Chalybion cyaneum*,[4] as was distinctly evident from the nature of the cocoon. Another, from the same kind of nest from Maud, Texas,[5] emerged May 21; this was from a cocoon that was distinctly *Trypoxylon*, evidently a renter in the nest made by a *Sceliphron* wasp. These localities are sufficiently near the Mexican border to be included in this list.

Monodontomerus n. sp. No. 1,477 [A. B. Gahan][6]

Many parasitic wasps of this species emerged from a cocoon of the pipe-organ wasp, *T. mexicanum*, at Kirkwood, May 25 to 28, 1939. The nest was taken in a hut at Jacala, in February.

Brachymeria mexicana D. T. [A. B. Gahan]

Parasites of this species emerged from four nests of the pipe-organ wasp, *T. mexicanum*, all of which were taken at one locality about 40 kms. south of Victoria. This species in emerging bites its way out of the old *Trypoxylon* cocoons, leaving its wet, sticky cocoon behind. The half-dozen adults emerged between May 16 and 31, 1939. The fact that the parasites transformed inside the wasp cocoons shows that probably the larva was not parasitized until late in its immature life—after the cocoon had been made.

Melittobia sp. [A. B. Gahan]

Many of these parasites emerged, March 16 to 20, from a nest of *Sceliphron* taken at Franklin, Texas, in February. They also emerged May 25 to 28, from cocoons of *T. mexicanum* taken at Jacala.

Amobia floridensis Tns. [D. G. Hall]

This fly belonging to the family Sarcophagidae made heavy inroads on the population of mud-daubers from three distinct regions, Franklin, Texas, San Antonio, Texas, and the location 40 kms. south of Ciudad Victoria. Those from Franklin emerged at Kirkwood May 16 to 21; those from San Antonio, April 10 to May 31; those from near Ciudad Victoria, Mexico, May 7 to 15. Whether they feed upon the wasps or upon their spider prey, I do not know, but it is likely that they do so on both, since in all cases no wasp larva had lived to be old enough to spin its cocoon.

Exoprosopa capucina Fab. [C. T. Greene]

These flies belonging to the family Bombyliidae emerged from nests of the Mexican mud-daubers brought to Kirkwood. The earliest

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[4]It is interesting to note that all of *Chalybion* from various points in Texas were identified by Miss Sandhouse as *cyaneum*.

[5]Moore and Maud, Texas, are 50 to 60 miles north of the border.

[6]A description of the new species will soon be published by Mr. Gahan.

date of their emergence was May 9, and the latest June 11, but the majority appeared between May 16 and 23. The nests were taken in February from culverts near the marker "Tropic of Cancer," on the International Highway, 40 kms. south of Victoria. They were heavily infested, probably a hundred flies emerging from 25 nests, the victims in the majority of cases being *Chalybion zimmermanni*. This fact was revealed, of course, by the condition of the old wasps' cocoons, which were made with webby covering. It is of interest to note that, while the infestation was heavy at this one collecting point, these flies did not occur in any of the material taken elsewhere on the Mexican trip.

Anthrax fur O. S. [C. T. Greene]

This fly, also belonging to the family Bombyliidae, heavily infested the mud-daubing wasps in the region 40 kms. below Victoria. They also emerged from the nests brought here from Franklin, Texas, and they are known to follow the same parasitic habits at St. Louis. The flies emerged from the Mexican nests June 7 to 11, and from the Texas ones on June 25.

Spogostylum sp. near **oedipus** Fab. [C. T. Greene]

One dead adult was found in a mud nest taken near Canyon de Galeana, Mexico, in February, and another of the same species was captured while it was hovering before some insect holes in a bank at Cuernavaca on February 22.

Triorophus nodiceps Lec [E. A. Chapin]

A half-dozen live beetles were taken from about 20 nests of the *Sceliphron* mud-dauber gathered from one culvert near Artesian Wells, Texas. Some of the beetles were in the open cells, some where in the debris at the bottom of the bag containing the lot, and one, I am sure, was in a sealed cell. Just what the relationship of this beetle is to the legitimate inhabitants of the nest, I do not know; but even though collections were made in several places in Texas and Oklahoma and on to Mexico City, no other nests gave evidence of this beetle.

BOOK NOTICES

THE AUTHOR PUBLISHER PRINTER COMPLEX, by ROBERT S. GILL, pp. i-iv and 76, 5 x 7.5 inches. 1940. Published by the WILLIAMS & WILKINS COMPANY, Mt. Royal and Guilford Ave., Baltimore, Md. Price, linen bound, $1.00.

The author of this gem is a philosopher who sees the problem of book production from the final form of the manuscript to the bound volume on the book sellers' shelves. With the mechanics of printing now tuned to clearances of a few thousandths of an inch, the wage schedules of the trade are such that printing and publishing rate as a profession. The printer and author in this tight environment of keenest competition have to co-operate as never before. The author has to know the difficulties the printer faces in attempting to turn out a uniform product from the author's manuscript. The printer has to have in his plant all the large and minute gadgets helpful to fine and fast printing. The necessity of the present volume: The printer can select and train his staff to the finest work at top speed (the level at which profits lie for the author and publisher) but the publisher cannot train the author. The present volume is a very well bred but firmly made suggestion to the author of a book that he should learn the printer's difficulties and co-operate as fully as possible.

The subject matter is arranged as follows: The Concepts Printing and Publishing; Royalties and Such; The Author as Collaborative Publisher; The Separate Functions of Author and Publisher; The Author's Manuscript; Fair Copy; The Ends and Oddments; Illustrations; Proof-Reading and Reading Proof; The Book Complete—and Revising It.

"Printing is not publishing. As measured by relative costs, printing is about a fourth or fifth part of publishing. * * * A certain portion of the list price of a book never reaches the publisher's coffers at all. It disappears in discounts to the retail trade. * * * The author is deserving of a royalty and this absorbs another ten to twelve per cent. * * * Advertising space, mail announcements, salesmen, and other direct charges takes another twenty to twenty-five per cent. General administration costs take another fifteen per cent. * * * Thus, without consideration of profit to the publisher or of cost of manufacture, something like seventy per cent of the list price is accounted for." Out of the remainder comes the cost of printing.

The Author Publisher Printer Complex is thus a summary of the many difficulties met by the budding author. It is the type of information that in the past has come to the scientific writer by word of mouth and in the course of actual and frequently bitter experience over a period of years. This dollar book should be read by all scientific writers and certainly should be in every laboratory library.—C. H. K.

FIELD PLOT TECHNIQUE, by WARREN G. LEONARD AND ANDREW G. CLARK. 271 pp. 1939. 8.5 x 10.75 inches. Published by BURGESS PUBLISHING CO., 426 So. Sixth St., Minneapolis. Multigraphed, paper bound. $3.25.

Agronomy and statistics are the combined themes of this workbook designed for senior and graduate students at Colorado State College. On the statistical side the manual is quite comparable in its contents and methods of presentation to other statistical texts for non-mathematical biologists. The novelty of this outline consists in the addition of a good deal of factual information about field experimentation and plant sciences to a well-organized treatise on biometry. This combination makes the book a comprehensive work on field plot technique, and, as such, recommends itself to the entomologist field worker as well as the agronomist. Incidentally, it should also prove of value to the teacher of statistics or laboratory biometrician, who, without agricultural training, may yet be frequently consulted on statistical matters in connection with field trials. Such persons will find this outline a convenient short course in agronomy.

Apart from the narrow inner margins causing a little difficulty in reading, this is an excellent specimen of multigraph printing. Its four parts contain 6 tables

and 21 chapters arranged as follows: Part I. Status of Agronomic Research—History of Basic Plant Sciences—Logic in Experimentation—Errors in Experimental Work. Part II. Frequency Distributions—Reliability—Binomial—Chi square—Correlation—Analysis of Variance—Covariance. Part III. Soil Heterogeneity—Size, Shape, and Nature of Field Plots—Competition—Simple Designs—Sampling Methods—Complex Experiments—Split-Plot Experiments—Confounding—Symmetrical Incomplete Blocks—Mechanical Procedure in Field Experiments.

A praiseworthy feature is the addition of full bibliographies and series of questions for discussion to each chapter. The chapters of Parts II and III are also provided with sets of problems and illustrative data. The Appendix (Part IV) contains, in addition to the usual chi square, *t*, *F*, and probability integral tables, tables of one-half Naperian logarithms, Bliss's angles of equal information for transformation of percentages for use in the analysis of variance, and Tippett's randon numbers.—C. W. C.

COMPARATIVE PSYCHOLOGY, VOL. II, PLANTS AND INVERTEBRATES, by CARL J. WARDEN, THOMAS N. JENKINS AND LUCIEN H. WARNER. Pages xiv and 1070, 168 figs., size 6 x 8.5 inches. 1940. Published by THE RONALD PRESS COMPANY, 15 East 26th St., New York. Price, cloth, $6.00.

This is volume II of the three-volume set on Comparative Psychology of which volume I, Principles and Methods, was given a notice in the ANNALS, XXVIII, p. 513, 1935, and volume III a notice in the ANNALS, XXIX, p. 297, 1936. Professor Warden is on the staff of Columbia University, Professor Jenkins is a professor of psychology in New York University, while Doctor Warner is on the staff of Opinion Research Corporation of New York City.

The contents are organized into seven massive chapters with ample subheads for ready reference. The headings are: I. Protista, Isolated Cells and Cell Cultures; II. Metaphyta; III. Porifera and Coelenterata; IV. The Echinodermata; V. Platyhelminthes, Nemathelminthes, Trochelminthes and Annulata; VI. Mollusca; VII. The Arthropoda. Bibliography. Author Index. Subject Index. The bibliography, while placed at the back, is organized by chapters.

This three-volume work is the most extensive and best organized review of experimental work on animal behavior that has been written. We give it and the two companion volumes notices in the ANNALS because volume I is an excellent analysis and review of such experimental methods, while this volume, in its chapter VII of 231 pages and the bibliography of that chapter, of 95 pages, gives a review at a length of 326 pages of all that is known in published experimental work on Arthropod behavior. Of course the greater part of the extensive chapter is on insect behavior. Two thousand two hundred and six papers were abstracted in work in this chapter. Their titles are given in the chapter's bibliography. The authors, in a general introduction, state that probably twice as many articles were reviewed as have been used and listed in the bibliographies. One feels that Volume II is a very dependable and practically complete review of the subject of experimental work on insect behavior. However in reading the paragraph on "Ballooning" which describes the habit as found in spiders, we discover that the fact has been overlooked that some forest caterpillars in young stages have the same habit of blowing with the wind.

Various specialists in the field of animal psychology have given approval of the earlier volumes as having been written from a point of view based on well established grounds. No personal points of view or special theories have been pushed by the present authors.

The organization of the material within a chapter is under types of behavior. Thus in succeeding paragraphs the discussion may turn from crabs to beetles. In a monographic work of this type we rather long for the elaborate analysis of chapter contents used in many German monographs. In the past we have usually thought of them as mere expressions of the author's ego but in a work of this type such an outline would be useful. On pages vii and viii the subheads are given to Chapter 7 but set solid in unleaded six point type, almost a full page in extent of barely legible material—but our eyes are not what they used to be.

This set of three volumes will be a necessity in all laboratories where a study of insect behavior is followed. It is a remarkably detailed review of methods and is one of the best documented works with which we are acquainted. A friend

well versed in the literature of ant behavior on going over the bibliography immediately found several valuable papers that she had failed to locate earlier in that field.

We can give this work the highest recommendation. It represents several years of work by the authors and certain of their helpful friends.—C. H. K.

MAMMALIAN GENETICS, by WILLIAM E. CASTLE. 169 pages, 131 figs. 1940. 6 x 9 inches. Published by HARVARD UNIVERSITY PRESS, Cambridge, Mass. Price $2.00.

Professor Castle, one of the pioneer geneticists of this country, presents here a textbook of heredity for the junior college or high school. Dealing almost exclusively with the genetics of mammals, man excepted, it is one of the few genetics texts thus confined to a single group of animals. Mammals are, of course, of greatest familiarity and interest to the average student, particularly the beginner. As an elementary text, it has the further advantage of being stripped of all that is technical and complicated in the usual college text. It treats only of the fundamentals of Mendelism and the traditional topics associated with heredity, of genes and their interactions, sex, hybrid vigor, maternal inheritance, variation and selection, etc. It includes little or nothing on chromosomes, aberrations, polyploidy, plant or human genetics, mathematics, evolution, or applications in plant and animal breeding. It may indeed be questioned whether the exclusion of some of these items makes the book fully suited as a text, even for beginners. But *Mammalian Genetics* is not a pretentious volume in any way; it is merely a well written, attractively printed, story of heredity and variation in mammals.

The high-light of the book is its thorough discussion of genetic variations in the laboratory rodents, culminating in the fifth chapter with a comparison of the genes and gene arrangements in these species. A novel and interesting chapter is one on the Major Contributions of Fish Genetics. The final chapter describes The More Important Gene Mutations of Domestic Mammals. Like the earlier chapters on rodents, it is well provided with photographic illustrations of the traits described. *Mammalian Genetics* is conspicuously free from pedigree charts, chromosome diagrams, formulae, graphs, problems, and checkerboards, such as fill the usual textbook of genetics.

The author has prepared a laboratory guide to accompany this book, also published by the Harvard University Press, but this has not been examined.

—C. W. C.

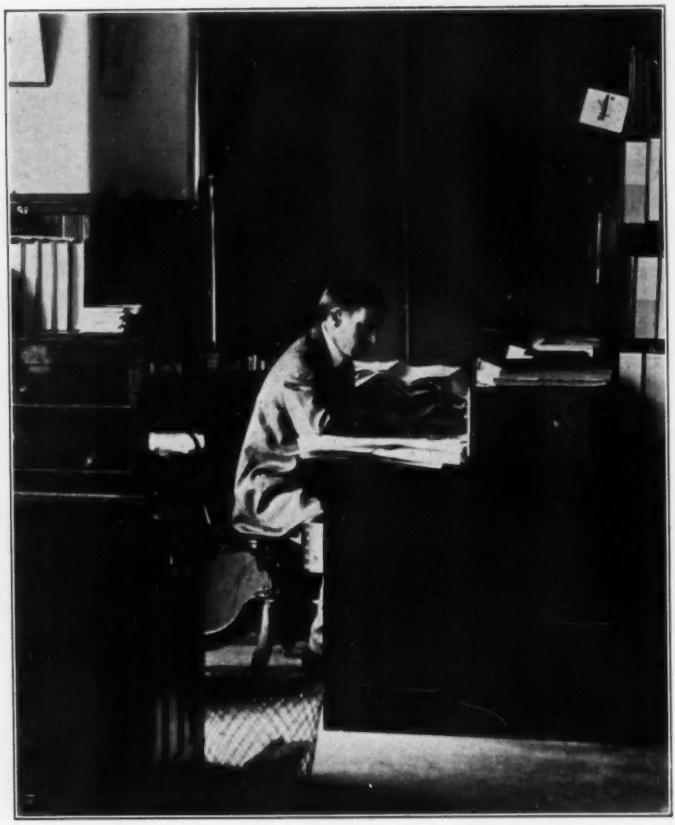
ABOUT SPIDERS, INTRODUCING ARACHNE, by ELAINE V. EMANS. Pages 183, 22 text figs. and 8 halftone plates. 5.5 x 8 inches. Published by E. P. DUTTON & CO., INC., 300 Fourth Ave., New York. Price, cloth, $2.50.

If Miss Emans could have had her interest in arthropods focused on ants instead of on spiders, English literature would have been enriched and an intensely interesting field of nature study would have been explored by a truly gifted writer. She is an author of verse for such journals as Good Housekeeping, Ladies Home Journal, Pictorial Review and Country Gentleman, and is a confirmed nature-lover.

While About Spiders is based much on personal observation by the author, it is not a scientific volume but is a charmingly written account of the lives of common American spiders. It is in a spirited, almost thrilling style, but shows good taste as regards scientific fact and the clever avoidance of raw teleological expression. Her writing indicates a mind for close observation and one rich in ideas. Thus Miss Emans has verbal expression under elastic but excellent control. About Spiders is an interesting, very readable book.

Some chapters are headed: 2. Eight Legs, Eight Eyes; 3. The Weaving of the Web; 4. The Mating; 6. Spider Motherhood; 8. Trapdoor Architects; 17. Arachnid Enemies; 19. In Conclusion. The halftone plates are from beautiful photographs by Lee Passmore and O. C. Kuehn. A few of the line drawings (Chapter XVI, The Economic Side) could have been spared, or are they an accent by contrast?

This volume is a simple, popular account to be recommended to all nature lovers and to all interested in the mechanics of writing for the popular field. Miss Emans has an inherent gift in her richness of expression but her writing has all the earmarks of rigorous training.—C. H. K.



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